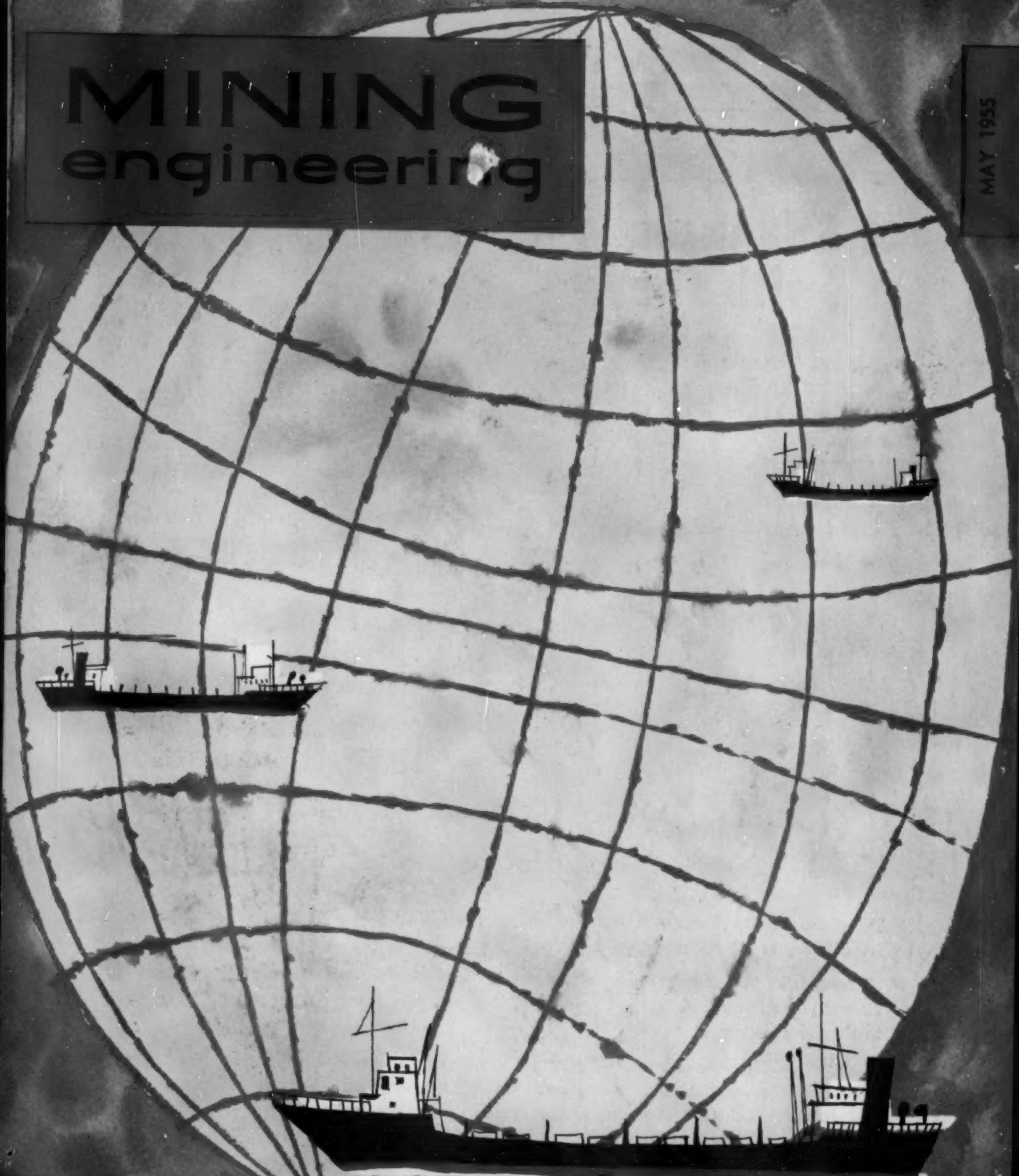
MINING engineering

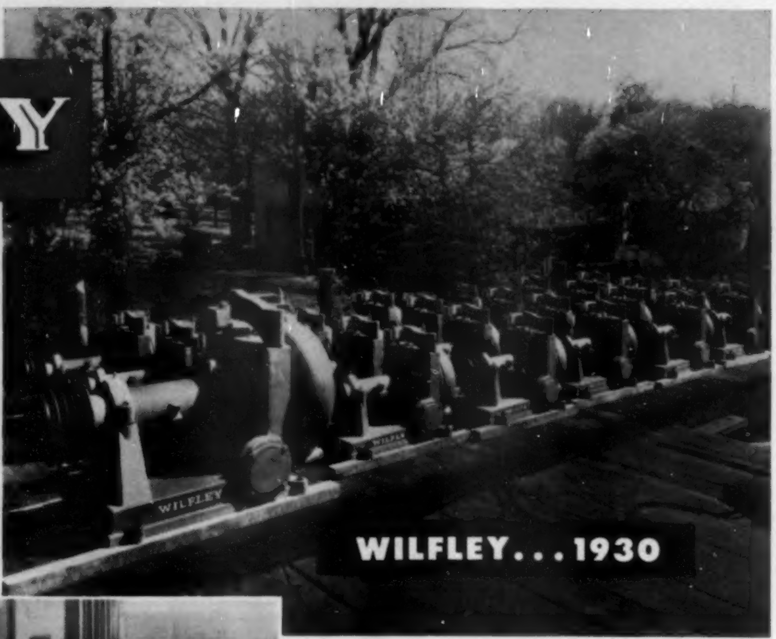
MAY 1955

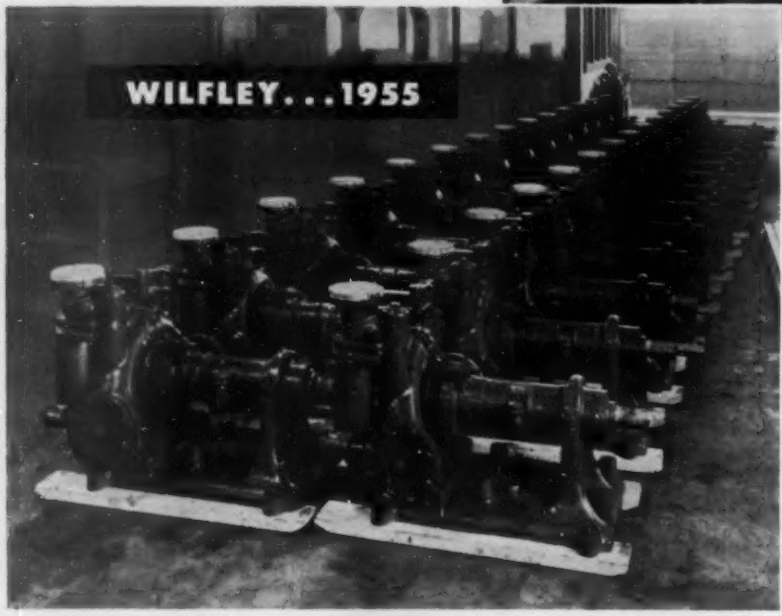


INTERNATIONAL MINERAL TRADE

WILFLEY

...Advances with the Mineral Industry





Progress in Low-Cost Pumping

Top photo (right) shows part of a large shipment of Wilfley Model "C" Sand Pumps ready for delivery to a large nickel producer.

25 years later this same company still depends on Wilfley for low-cost pumping. Shown in bottom photo is part of a large shipment of Wilfley's new Model "K" pumps on their way to the same customer.

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MINING engineering

VOL. 7 NO. 5 MAY 1955

COVER

With this issue MINING ENGINEERING starts a series of articles on international mineral trade, by John Ridge. The cover announcing the series is by artist Herb McClure.

FEATURES

ARTICLES

TRANSACTIONS

PERSONNEL

THE following employment items are made available to AIME members on a nonprofit basis by the Engineering Societies Personnel Service Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18**; 100 Farnsworth Ave., **Detroit**; 57 Post St., **San Francisco**; 84 E. Randolph St., **Chicago 1**. Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Petrographer-Geologist, A.B., M.S. in geology. Experienced petrographer with training in mineralogy and spectrographic analyses. Some X-ray diffraction experience. M-224.

Development Executive. Experienced registered engineer, 45; available on termination of present overseas contract in charge of research and development group in large mining organization. Proven ability in technical administration and metallurgical operations in U. S. and foreign fields, as well as thorough background in modern processing of ores and metals. M-222.

Engineering Graduate, major in mining, married, 26. Two years Army service. Will receive M.B.A. degree from Harvard Graduate Business School in June. Desires work leading to responsible administrative position in a mining or manufacturing organization. Interested all phases of operations, chiefly production. M-223.

POSITIONS OPEN

Engineers. (a) Assistant Mine Superintendent, with at least 3 years underground experience in metal mine. Salary, $6000 a year. (b) Master Mechanic with at least 3 years mining equipment maintenance experience. Salary, $4800 a year. Location, foreign. F1202.

Mining Engineer for technical service; work involves development, manufacture, sales, and use of commercial explosives. Recent graduate or man with limited experience preferred. Location, Southwest. W1369.

Mining Engineer, graduate, 35 to 50, experienced in underground mining that calls for heavy timbering work, such as used in mining high quality talc; experience must be in timbering and vertical stoping. Must be able to lay out and inspect all work personally and work with and under owner. Salary, $7500 to $10,000 a year. North Carolina. W1222.

Safety Engineer, mining, with mining and safety engineering experience, including preparation of reports. Considerable traveling to properties in eastern states. Salary, $6000 to $8000 a year. Headquarters, Pennsylvania. W1193.

Mine Superintendent, graduate, experienced in the supervision of underground mining. Knowledge of Portuguese desirable. Salary, $12,000 a year, U.S. currency; traveling expenses for applicant and family paid; housing provided. Three-year contract. South America. F1365.

Metallurgical Engineer, graduate in metallurgy, with ore concentration experience, preferably including operation, design, construction, and research (ore testing) for research and development. Salary, $6000 to $7200 a year. Colorado. S718.

POSITION AVAILABLE

Graduate engineer thoroughly experienced open-cut mining, preferably with Latin-American operating background needed for preparation estimates later operation location South America, salary open. Send full professional record, salary desired, references.

Box 6-F AIME
29 West 39th St., New York

MINERAL OR METALLURGICAL ENGINEER for development department of major chemical company expanding operations based on mineral deposits. Prefer age 30-40 and at least 10 years ore processing experience, particularly non-metallic, including estimation of capital and operating costs. Salary range $8-10,000. Mountain state location.

Box 3-E AIME
29 West 39th St., New York 18, N. Y.

POSITION AVAILABLE

Graduate engineer to manage mining property producing two hundred tons per day, located in the Andes of Southern Peru. Must speak Spanish, preferably Latin-American operating experience. Send professional record and salary desired to:

Box 5-F AIME
29 West 39th St., New York

MECHANICAL ENGINEER

Who has specialized in ball and tube mill application, to be associated with reliable manufacturer and to act as liaison between sales and engineering departments. Good salary and bonus to right man.

Box 4-F AIME
29 West 39th St., New York 18

Graduate mining engineers with 4 or 5 years varied experience are required by large, progressive, expanding, copper mine in the copperbelt of Northern Rhodesia.

Successful applicants will be given further experience in all phases of the mine technical and production departments including ventilation, draw control, survey, sampling, geology, planning and design, practical work on grizzleys, scraping, tramming, timbering and rock breaking, in order to fit them to progress to various responsible positions in the mining department. Basic salary will be dependent upon experience, but will not be less than £80 per month. There is in addition a variable cost of living allowance at present amounting to £6.10.0d p.m., together with pension, life assurance and medical schemes, in which the successful applicants will participate. There is also a copper bonus scheme based on the prosperity of the copper mining industry, which at present amounts to 60 per cent on basic salary.

Leave would be initially at the rate of 43 days per year, and can be accumulated for three years. Single quarters only are available in the first instance, married accommodation being allocated on the basis of length of service. The waiting period for married accommodation is at present approximately one year.

Travelling expenses to Northern Rhodesia will be paid for successful applicants. Applicants should submit details of age, qualifications, experience, marital status, availability and references to Box 563, Walter Skinner Ltd., 20 Copthall Avenue, London E.C.2, England.

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Young Mining Engineer interested in production work. Limestone mine in Central U. S. location. Excellent growth opportunity. Experience not essential. Submit complete resume and salary requirement in first letter.

Box 7-F AIME 29 West 39th St., New York 18, N. Y.

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BOOKS

Geology in Engineering, by John R. Schultz and Arthur B. Cleaves, *John Wiley & Sons Inc.*, $8.75, 592 pp., 1955.—This is a systematic account of geology from the viewpoint of its application in civil engineering. Designed both as a text and a practical reference, this book places considerable emphasis on soils and the application of geology to soil mechanics. Mr. Schultz is chief, Geology Branch, Waterways Experiment Station, Vicksburg, Miss., and Mr. Cleaves is professor of geology, Washington, University, St. Louis.

Moving the Earth, The Workbook of Excavation, by Herbert L. Nichols, Jr., *North Castle Books*, $15.00, 1280 pp., 1264 ill., 1955.—See *Drift*, page 451.

The Geology of Ireland, by J. K. Charlesworth, *Oliver & Boyd*, Edinburgh, approximately $3.50, 276 pp., 1953.—Written for first-year geology students and the general reader, this is a concise treatment of the geological history of Ireland from the pre-Cambrian era to the present, covering stratigraphy, fauna, structure, igneous rocks, geomorphology, and mineral resources. The text is fully illustrated with photographs and drawings.

ORDER YOUR BOOKS THROUGH AIME—Address Irene K. Sharp, Book Department. Ten pct discount given whenever possible.

Physical Chemistry and Metal Extraction, by D. W. Hopkins, *Macmillan Co.*, $4.80, 232 pp., 1954—The emphasis in this book is on applications, with three chapters devoted to process techniques which can be used in a wide variety of conditions in roasting, reduction, and oxidation. Two chapters deal with particular processes: iron smelting in the blast furnace and zinc extraction by the retort process. A brief review of the theoretical basis is presented in the opening chapters. Extensive supplementary bibliography.

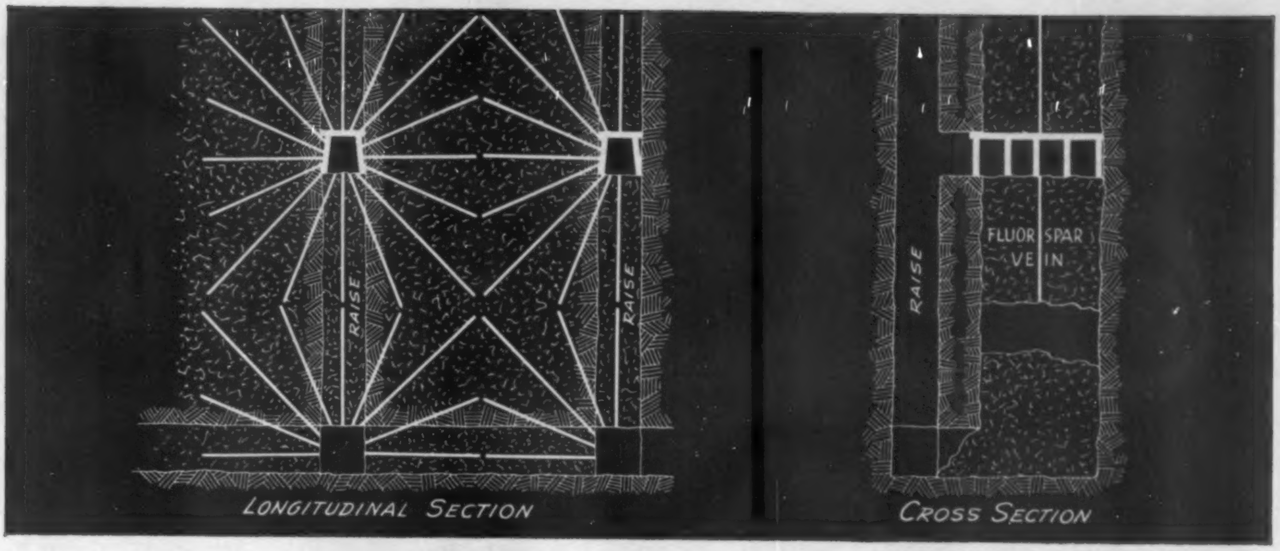
Depreciation, by Eugene L. Grant and Paul T. Norton, Jr., *Ronald Press Co.* $7.50, 504 pp., 1955.—This comprehensive manual for engineers, accountants, and industrial managers deals with depreciation from the point of view of accounting and income taxes, and with the uses and limitations of depreciation account figures as a guide to decisions on business problems. The revised printing has a new chapter on the Internal Revenue Act of 1954 as it affects the rules governing depreciation tax practice.

Petrology for Students, An Introduction to the Study of Rocks under the Microscope, by Alfred Harker, *Cambridge University Press*, $3.50, 283 pp., 8th ed., 1954.—A new edition of a standard British manual for geology students. Separate sections are devoted to three types of igneous rocks, to sedimentary rocks, and to metamorphism, and a brief introduction covers elements of optical properties and methods of examining specimens.

Geochemistry, by the late V. M. Goldschmidt, edited by Alex Muir, *Oxford University Press*, $10.10, 730 pp., 1954.—The first part of this work deals with general topics; distribution of elements during evolution of the earth; evolution of rocks from liquid magma; rock weathering and sediment formation; chemical composition of the universe as a whole; and geochemical aspects of crystal chemistry. The second part, comprising over three quarters of the book, is a detailed study of the abundance and occurrence of the individual chemical elements, with separate chapters devoted to each element or group of elements.

Steam, Its Generation and Use, 37th edition, *The Babcock & Wilcox Co.* $10.00, 22 chapters, 1955.—The first edition of this book appeared in 1879. All material of the current edition was prepared and edited by engineers and specialists of the Babcock & Wilcox Co. It is intended primarily for mechanical engineers and mechanical engineering students in the applied thermo field.

(Continued on page 422)



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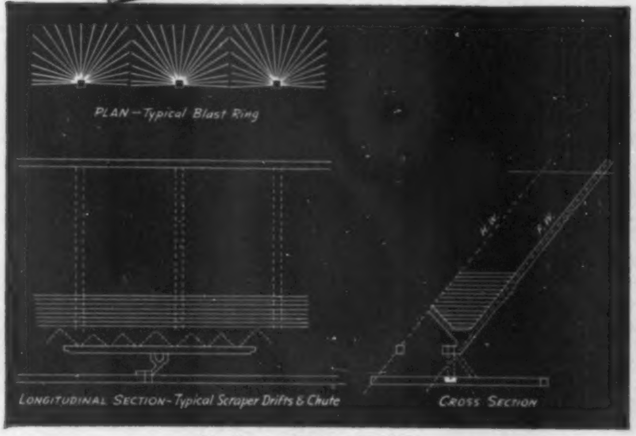
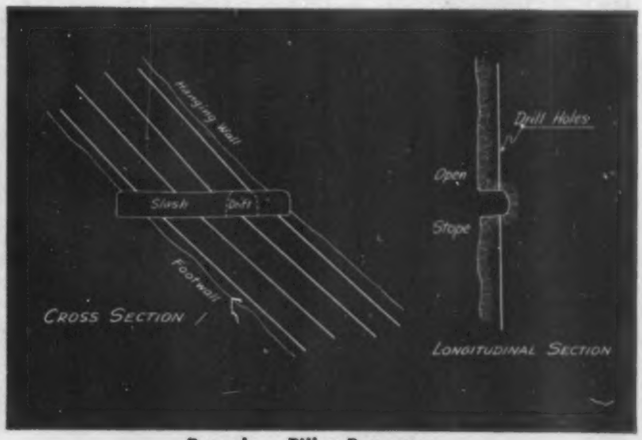


Horizontal Ring Drilling



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Estimation de la valeur de la production minière mondiale en 1950, by F. Blondel and E. Ventura, available from M. J. Dumas, 5, rue Jules Lefebvre, Paris 9°, France, 600 francs, 58 pp.—Taken from the *Annales des Mines* for October 1954, this article, a portion of which is translated into English, is based on a detailed analysis of about 100 countries and 50 minerals. A comparison is made between mineral production and national income; breakdowns show the world mineral production according to categories and subcategories of minerals; according to countries and continents, etc. World mineral production for 1950, seemingly a good year for reference, should have amounted to $27.5 billion.

Colorado Mining Laws, with Rules and Regulations, Bulletin No. 16, *Colorado Bureau of Mines,* Museum Bldg., 14th Ave. & Sherman St., Denver 2, Colo., $1.00 (free to miners and mine operators actively engaged in Colorado mining), 246 pp., June 30, 1954.

The Treatment of Sewage Plant Effluent for Water Reuse in Process and Boiler Feed, by R. J. Keating and V. J. Calise, Technical Report T-129, *Graver Water Conditioning Co.,* 216 W. 14th St., New York 11, NY, free, 6 pp., illustrated.

California Journal of Mines and Geology, Volume 50, Nos. 3 & 4, July-October 1954, *Div. of Mines,* Ferry Bldg., San Francisco 11, Calif., $2.00, 780 pp.—This issue contains "The Cool-Cave Valley Limestone Deposits, El Dorado and Placer Counties, California," by William B. Clark, "Mines and Mineral Deposits of Los Angeles County, California," by Thomas E. Gay, Jr., and Samuel R. Hoffman, and "Annual Report of the State Mineralogist, Chief of the Division of Mines, for the 105th Fiscal Year," by Olaf P. Jenkins.

Occurrences of Uranium Ores in New Mexico, Jan. 15, 1955, compiled by E. C. Anderson, Circular 29, *New Mexico Bureau of Mines & Mineral Resources,* Socorro, N. M., free, 40 pp., mimeographed.

Geology and Mineral Deposits of Barstow Quadrangle, San Bernardino County, California, by Oliver E. Bowen, Jr., Bulletin 165, *Div. of Mines,* Ferry Bldg., San Francisco 11, Calif., $3.00, 208 pp., 84 fig., 9 pl., 1954.—One of the few detailed studies of a region covering nearly 1000 sq miles in the heart of the Mojave Desert. Also included is a short paper, "Thermal Properties of Ceramic Materials from Barstow Quadrangle, California," by Joseph A. Pask and Oliver E. Bowen, Jr. The two maps, plates 1 and 2, and a series of structure sections comprising plate 3 may be purchased separately for $1.00.

Geology of the Silver Lake Talc Deposits, San Bernardino County, Calif., by Lauren A. Wright, *California Div. of Mines,* Ferry Bldg., San Francisco 11, Special Report 38, $1.00, 30 pp., 4 pl., 18 fig., 1954.—These deposits, located in the Mojave Desert of southeastern California, have yielded a steady production of talc for the past 35 years. Talc mined from the deposits recently has gone chiefly into the manufacture of wall tile, though previously it was used by the ceramic, paint, and rubber industries. The author, a member of the staff of the California Div. of Mines, has included as an appendix a discussion of the petrography and metamorphism of the principal rock units.

Mineral Resources of Fort Defiance and Tohatchi Quadrangles, Arizona and New Mexico, by John Eliot Allen and Robert Balk, Bulletin 36, *State Bureau of Mines & Mineral Resources, New Mexico Institute of Mining & Technology,* Campus Station, Socorro, N. M., $2.50, 192 pp., 1954.—"No mineral resources are being exploited currently . . . Coal and nonmetals have commercial possibilities, but metallic minerals found . . . consist solely of a few traces of manganese oxides in sandstone concretions." This comprehensive, well-illustrated survey includes a list of Navajo words used for geologic terms. The Navajos, the authors report, make excellent prospectors.

(Continued on page 428)

CRUSHERS

In the Allis-Chalmers line of gyratory crushers there are high capacity *Superior* crushers for primary and secondary crushing and the hydraulically adjusted *Hydrocone* crushers for secondary and tertiary crushing. Other crushers available from Allis-Chalmers include four types of jaw crushers, a line of roll crushers, and a multi-impact hammermill.

In the *Hydrocone* crusher (illustrated) hydraulic control makes possible quick, accurate size adjustment, simplified compensation for wear and fast emergency unloading. Adjustment is a one-man, one-minute pushbutton or hand crank operation.

Mainshaft assembly is supported on hydraulic jack. Oil pumped into or out of jack raises or lowers shaft.

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Allis-Chalmers manufactures mills in a maximum range of sizes—your assurance of getting the most suitable mill for a given purpose. Mill types include:

Rod Mills—for wet or dry (4 to 20 mesh) grinding.

Ball Mills — for wet or dry (20 to 200 mesh) grinding.

Pebble Mills—for grinding with non-metallic grinding media and liners where iron contamination is objectionable.

Ballpeb and *Compeb* Mills — for fine grinds; stage grinding in multi-compartment types.

Illustrated on opposite page is a 9 by 12 Allis-Chalmers dry grinding peripheral discharge rod mill.

SCREENS

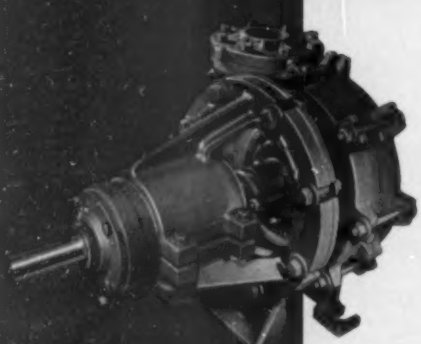
The Allis-Chalmers line of vibrating screens includes:

Aero-Vibe Screen — for medium to fine sizing of lump or granular material. Available with *Sta-Kleen* deck or *Thermo-Deck* heating unit.

Ripl-Flo Screen — for scalping, coarse and fine sizing. Available with *Sta-Kleen* deck (rubber balls below cloth), and *Thermo-Deck* unit.

Low-Head Screen — for wet or dry screening, rinsing or dewatering. Available with *Sta-Kleen* deck for fine sizing.

ALLIS-CHALMERS

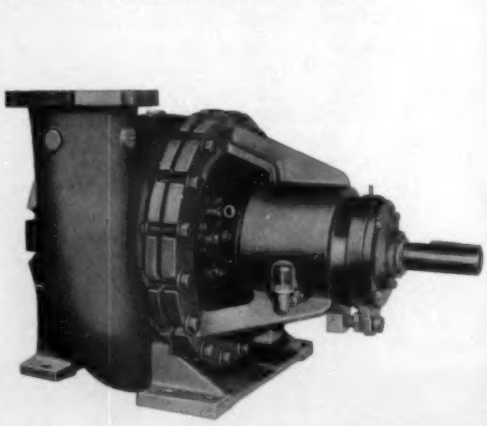


SOLIDS HANDLING PUMP

Type NRL, Rubber-Lined — This Allis-Chalmers pump is lined with special rubber compounds engineered to fit each application. Original capacity and efficiency are maintained over long periods. Records show that the Allis-Chalmers rubber-lined pump has a service life of 10 to 50 times greater than the finest alloy pump when handling finely divided, highly abrasive materials.

TYPE CW—This pump is recommended for pumping larger particles. Designed for heavy duty, the Type CW pumps are made of wear-resisting *Allisite* hard iron alloy and *Ni-Hard* nickel alloy.

In both pumps, assembly and disassembly are simplified by special construction. Inspection and repair may be made with a minimum loss of production time.



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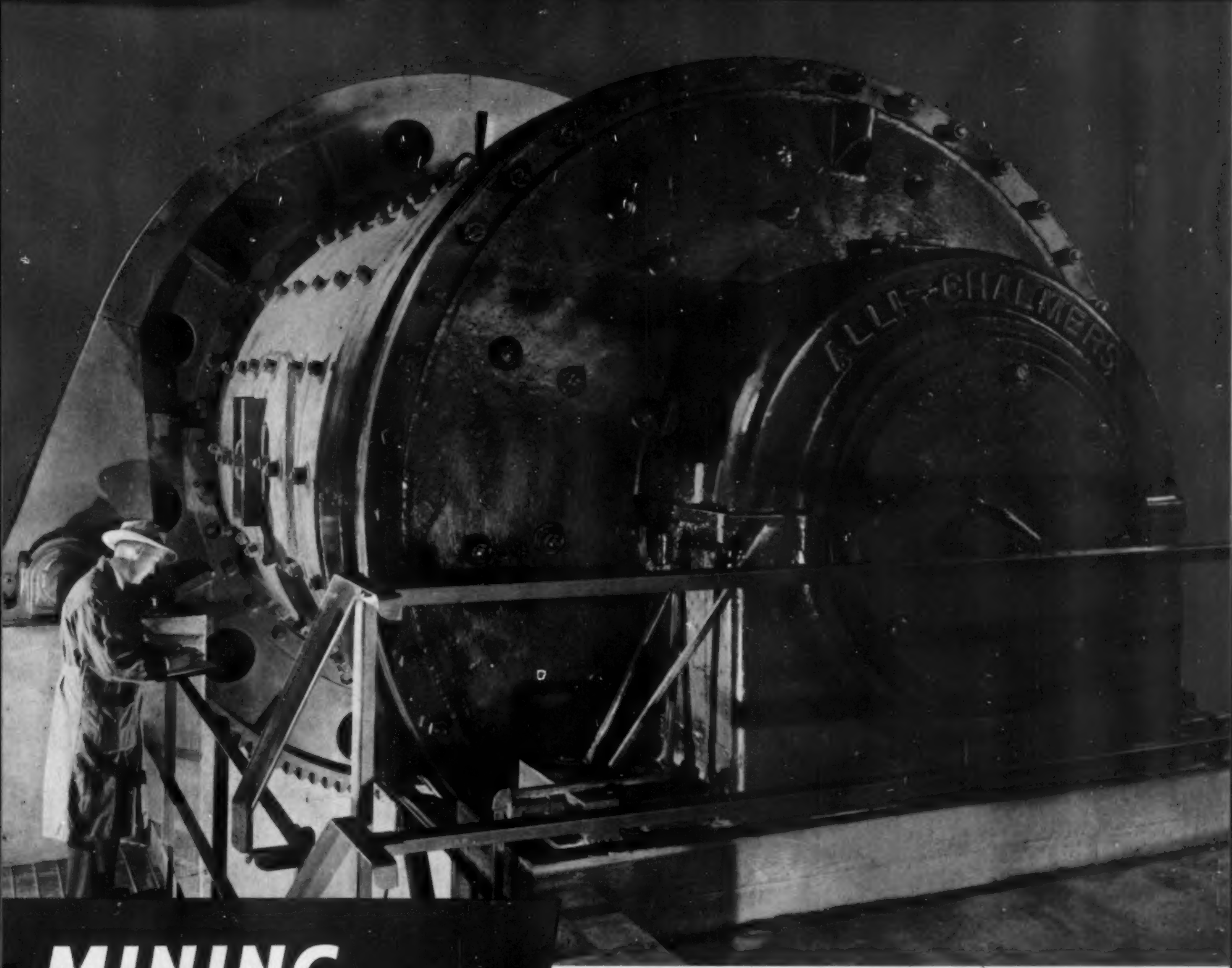
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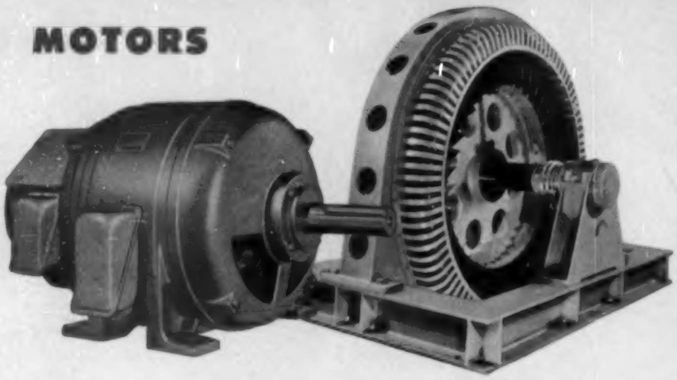
ALLIED ELECTRICAL EQUIPMENT

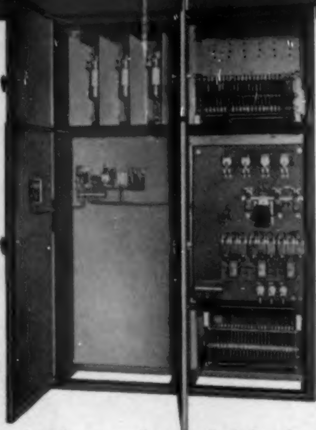
MOTORS



Allis-Chalmers builds a complete line of motors from ½ horsepower up for every industrial use. In addition to cage motors, the types most applicable to the mining industry are the wound rotor and synchronous motors.

Wound Rotor Motors are used for constant speed duty requiring frequent reversing or starting under heavy load; high starting torque applications. Ratings range from 5 hp up.

Synchronous Motors are applicable to most constant speed drives. Operating characteristics include high efficiency and the ability to improve system power factor.



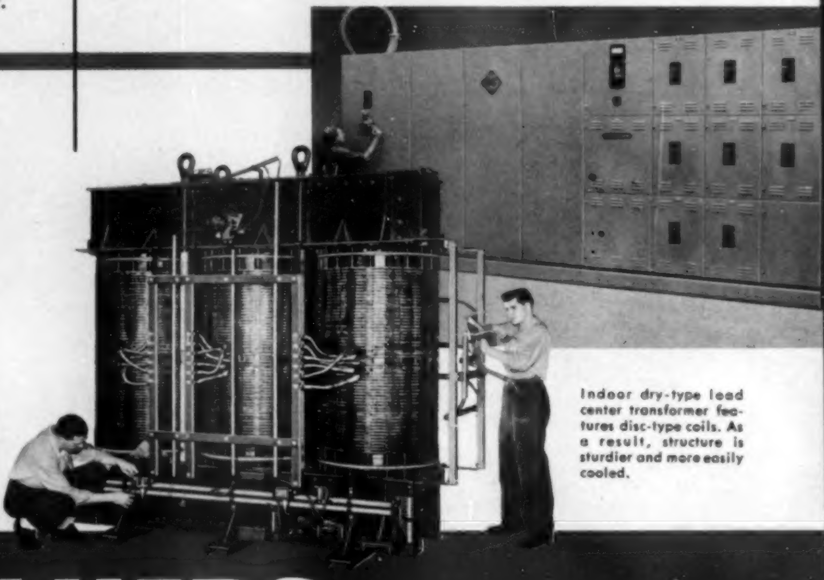
CONTROL

As manufacturers of a diversified line of industrial equipment, Allis-Chalmers has been called to solve thousands of control problems. This specialized experience is yours when you specify Allis-Chalmers control.

The control illustrated features circuit designed to cut costly down time in the rough-tough job of rock and ore crushing. *Motor overload protection* is provided by two sets of thermal overload relay. One set operates on slight overload to sound warning. Second set stops motor when temperature reaches danger point. Control is arranged so that *maximum starting torque* can be obtained at any time while motor is being started. *Jog controller* permits rocking to clear jam. *Time-delay undervoltage relay* allows riding through momentary voltage dips. On currents greater than normal load peaks, motor is disconnected through an *instantaneous current relay.*

UNIT SUBSTATIONS

Allis-Chalmers load center unit substations step down voltages . . . distribute power . . . protect circuits, equipment and personnel. Completely factory assembled, transformer, switchgear and control combinations are integrated in one attractive, easy-to-install enclosure. Compact and flexible, these units can be strategically located to bring high voltages near load centers with resultant economy in cable cost, minimum line loss and efficient voltage regulation.



Indoor dry-type load center transformer features disc-type coils. As a result, structure is sturdier and more easily cooled.

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Bulletin 07B6166L covers all equipment manufactured by Allis-Chalmers for the mining industries. Individual bulletins covering specific equipment lines are also available.

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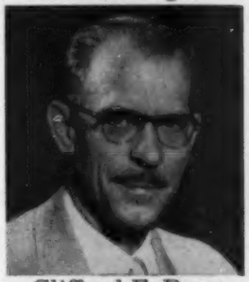

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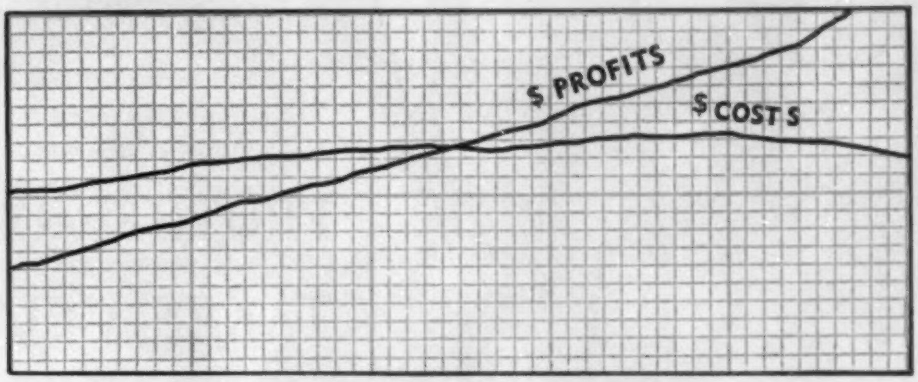

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DECO Engineers will help you work out the flowsheet which will give you an operation that is simple, efficient and most profitable. Many typical flowsheets are at your disposal and may apply to your specific problem.

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. . . up to 500 tons per hour handling feeds ranging to power shovel size

The SYMONS Type-K vibrating manganese Bar Grizzly is recommended for large tonnage *Scalping* of ore, rock or gravel. The powerful vibrating action of the Bar Grizzly makes it particularly effective for wet, sticky or gummy materials. The sloping, curved bars of the Symons Bar Grizzly tend to cascade the material as it passes over the screening surface. The tumbling action effectively assists in separating the undersize. Will handle feed sizes up to 30″ and larger.

FOR HEAVY DUTY SCALPING SERVICE

For full details about the SYMONS BAR GRIZZLY, send for BULLETIN 121A.

For full details about the SYMONS ROD GRIZZLY, send for BULLETIN 207.

SYMONS VIBRATING ROD GRIZZLIES

. . . up to 500 tons per hour for feeds up to 10″ — 12″

The SYMONS Type-K—RG vibrating Rod Grizzly is built for heavy duty scalping service in large tonnage operations . . . bridging the gap between primary breaking and the secondary crushing and screening operations. It can readily handle dry, wet, sticky or gummy ores and rock. Some of the important features include:

Abrasion resistant heavy spring steel rod screening surface; Long lasting, low cost rods are easily adjusted or replaced; Effective, vigorous vibration provides thorough scalping; Amplitude of vibration can be quickly and easily changed to meet various operating conditions. Ideally suited for service following most sizes of primary crushers and scalping operations requiring relatively coarse separations in the range between 1″ to 4″.

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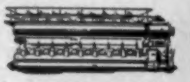
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Geology and Ground-Water Resources of Wichita and Greeley Counties, Kansas, by Glenn C. Prescott, Jr., John R. Branch, and Woodrow W. Wilson, Bulletin 108, 134 pp., 13 fig., 7 pl., April 1954. Mailing charge 25¢. **Additional Studies of the Cenozoic of Western Kansas,** by Daniel F. Merriam and John C. Frye, Bul. 109 part 4, 16 pp., 2 pl, May 1954. Mailing charge 10¢. **Thickness Maps of Criteria of Regional Structural Movement,** by Wallace Lee, Bul. 109 part 5, 16 pp., 10 fig., May 1954. Mailing charge 10¢. These bulletins are available from the *State Geological Survey of Kansas,* University of Kansas, Lawrence, Kans.

Directory of Commercial and College Testing Laboratories, *American Society for Testing Materials,* 1916 Race St., Philadelphia 3, Pa., $1.00, 48 pp., 1955.—This is a successor to the *Directory of Commercial and College Laboratories* published in 1947 by the Dept. of Commerce, National Bureau of Standards, as Miscellaneous Publication M 187. Information is given concerning 278 commercial testing laboratories and their 151 branches or offices. There is also a list of the laboratories of 86 colleges that are prepared to do testing under certain conditions.

ASTM Standards on Coal and Coke (With Related Information), prepared by ASTM Committee D-5 on Coal and Coke, *American Society for Testing Materials,* 1916 Race St., Philadelphia 3, Pa., $2.25, 164 pp., September 1954.—In this 1954 edition 27 methods of tests, definitions, and specifications for coal and coke and the standard specification for the classification of coal according to rank and grade are included. In previous editions this compilation has been widely accepted and used by the coal and coke industry and by industries and agencies purchasing these fuels in carload or greater lots.

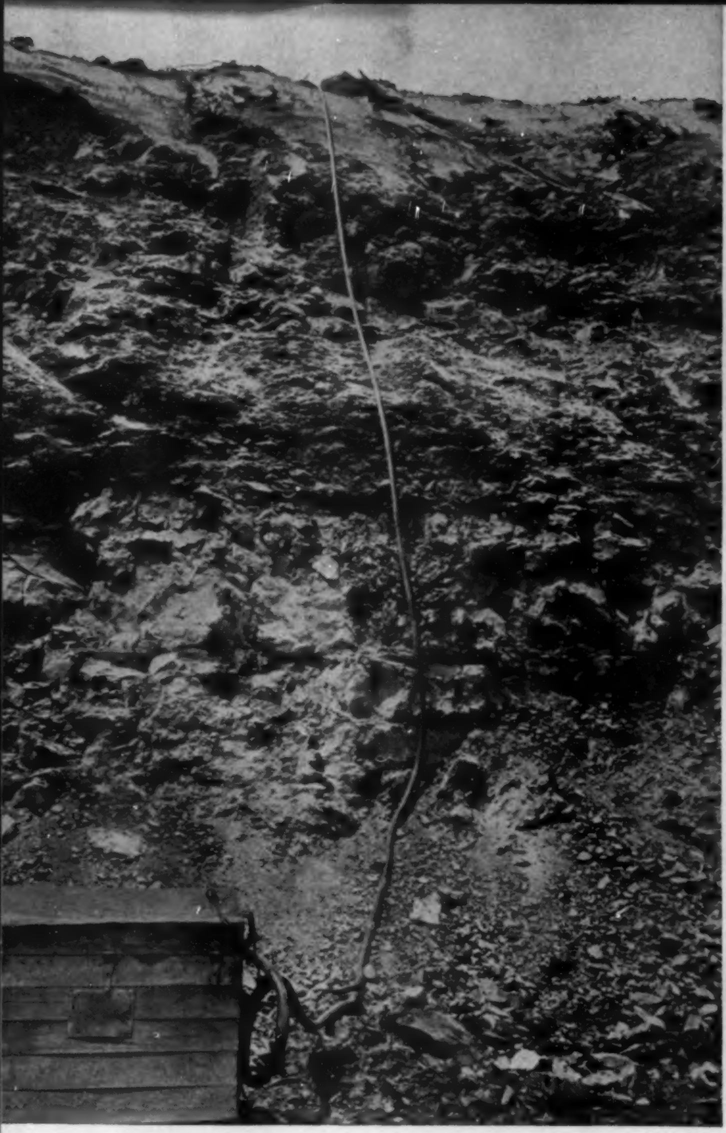
Guide Book, Fourth Annual Field Conference, Banff-Golden-Radium, *Alberta Society of Petroleum Geologists,* Box 141, Calgary, Alberta, $7.50 Can., 182 pp., 1954.—The stratigraphy and structure of the southern Rocky Mountains of Canada and summary descriptions of the mineral deposits, igneous rocks, and coal deposits of the area. A separate folded map of the region, a chart of structural sections, and a list of maps accompany the 11 papers.

Cambrian Cephalopods, by Rousseau H. Flower, *State Bureau of Mines & Mineral Resources, New Mexico Institute of Mining & Technology,* Campus Station, Socorro, N. M., Bulletin 40, $1.00, 51 pp., 1954.—An investigation based on the description and classification of new material from the Upper Cambrian of the Llano uplift in Texas.

Correlation Chart of Uranium Bearing Minerals, *Colorado School of Mines Research Foundation Inc.,* Golden, Colo., $5.00 postpaid.—Containing over 160 uranium-bearing minerals, this 50x32-in. chart is divided into vertical chemical-radical columns and horizontally into chemical-element bands, each of a different color for greater visual ease of correlation. Each mineral is contained within a box, located upon the chart in accordance with the mineral's chemical components. Practically all the physical characteristics necessary for identification are given under each mineral.

Geologic Maps of Indiana: **Preliminary Coal Map No. 2,** Distribution, structure, and mined areas of coals in Sullivan County, Ind. 50¢. **Preliminary Coal Map No. 3,** Distribution, structure, and mined areas of coals in Pike County, Ind. 50¢. **Coal Investigations Map No. C 11,** Geology and coal deposits of the Dugger quadrangle, Sullivan County, Ind. $1.50. **Coal Investigations Map No. C. 17,** Geology and coal deposits of the Shelburn quadrangle, Sullivan County, Ind. (Maps C11 and C17 published by the USGS in cooperation with the Indiana Geological Survey) $1.50. Available from Publications Section, Geological Survey, *Indiana Dept. of Conservation,* Indiana University, Bloomington, Ind.

MINE POWER CABLE



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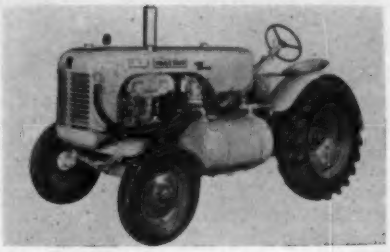
Compressor-Tractor

Air output of the *Le Roi* Tractair has been increased from 105 to 125 cfm. The combination 125-cfm compressor and 35 hp wheeled tractor is



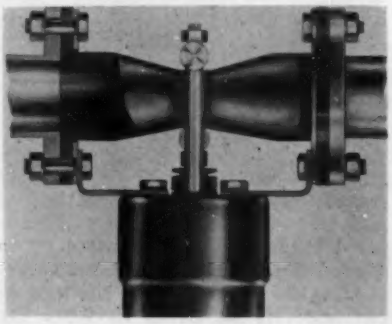
designed to bring compressed air to otherwise hard-to-get-at places. New standard equipment includes additional piping, large carburetor, and aftercooler. **Circle No. 1.**

Wire Rope

A line of wire rope with steel cores offering 15 pct greater strength than the strongest grade heretofore marketed is reported by *John A. Roebling's Sons Corp.* Higher resistance to wear from bending and abrasion, and longer life are claimed for new rope made in sizes from ¼ to 3½ in. **Circle No. 2.**

Flanged Valves

R. K. L. Valve & Mfg. Co. has new line of straight-through flow, pinch



type valves for handling corrosive materials or abrasive slurries. Pinching mechanism is air operated. **Circle No. 3.**

Scraper

Allis-Chalmers Mfg. Co. has a new motor scraper, the TS-360, in production. Weighing 49,000 lb, the scraper has 15 cu yd struck capacity, 20 cu yd heaped capacity and features a new 280-hp Allis-Chalmers diesel engine. Gears, shifts, and bearings have been re-engineered for extra-long life. A completely new tractor main frame makes possible all the advantages of "unit construction," facilitating easy removal and servic-

ing of both major and minor assemblies. **Circle No. 4.**

Safety First

New Skullgard plastic safety helmet introduced by *Mine Safety Appliances Co.* is reported to offer added protection to workers on jobs

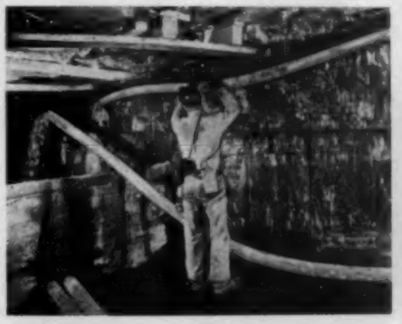
involving possible head injury. The helmet is designed to offer extra protection in what is described as the danger zone—front, top, and back areas of the hat exposed most often to impact. Special reinforcement is incorporated in the Skullgard. **Circle No. 5.**

Better Transits

Charles Bruning Co. Inc. has issued a brochure describing what the firm calls the "first real development in surveying instruments in 100 years." Dustproof, ballbearing construction of Brunson instruments is said to insure retention of accuracy. Transits are available in engineer's, light mountain, and night illuminated models. **Circle No. 6.**

Plastic Pipe

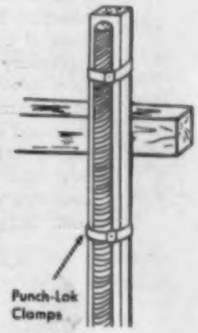
Featherweight plastic pipe, produced by National Tube Div., *U. S.*



Steel Corp., has been reported successful in tests at U. S. Steel's Leisenring No. 2 mine. Flexibility and corrosion resistance are two claims made for the pipe, in addition to the fact that a 200-ft coil of 2-in. plastic pipe weighs only 86 lb. It can be installed to meet any contour of mine bottom or roof. **Circle No. 7.**

Special Clamps

Hose clamps made by *Punch-Lok Co.* can help mine operators suspend heavy armored electric cable in vertical mine shafts. Workmen have to carry only the clamps and the locking tool; no drills, screwdrivers, or other tools are needed. **Circle No. 8.**



Big Crawler

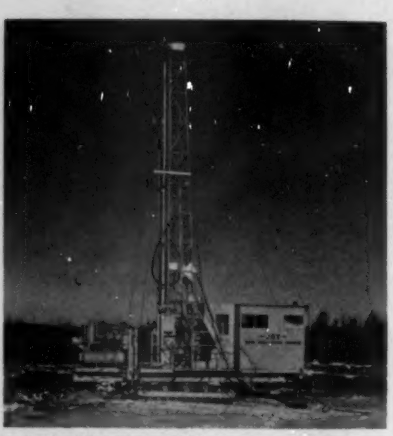
The Cat D9 tractor has been added as the sixth *Caterpillar* track-type in the company's line. The D9 is a 56,000 lb, 230-drawbar hp crawler trac-

tor with turbocharged 6-cylinder engine. It is said to be the world's largest, most powerful production crawler and climaxes ten years of big tractor research. The tractor will have a oil-type clutch or optionally a torque converter, in-seat starting, hydraulic track adjustment, and many servicing conveniences, in addition to claimed excellent operator visibility. **Circle No. 9.**

Rotary Drill

A new, larger model has been introduced to the *Joy Mfg. Co.* Champion line of blasthole drills, the Super Heavyweight Champion (Model 60-BH), a rotary-air blast drill designed for 9 to 12 in. holes in any

(Continued on page 432)



rock formation. Extra features are a rod handling device and power air swivel; a variable speed motor operating through a five-speed transmission to give sufficient torque to any desired bit rpm and any desired tramming or hoisting speed; and fully automatic hydraulic chuck. **Circle No. 10.**

Sensitive Counter

Nuclear Instruments & Chemical Corp. has a new uranium prospecting instrument, the model 2613 Oracle. With the Oracle a large area can be covered and a 0.1 pct uranium

sample gives a good indication of find importance. Sensitivity is supplied by an exclusive cluster of 10 specially treated Geiger tubes. According to the company, changes in radioactivity as small as 0.001 mr per hr can be read. **Circle No. 11.**

News and Notes

Sauerman Bros. Inc. has moved its general offices to 620 S. 28th Ave., Bellwood, Ill., adjacent to the Bellwood plant and in a structure providing enlarged facilities . . . American Locomotive Co. has changed its name to *Alco Products Inc.* to reflect the increasing diversity of company operations . . . Patent and manufacturing rights to the Braun line of laboratory apparatus have been acquired by *Bico Inc.*, 3116 Valhalla Drive, Burbank, Calif., who now supply wide range of assay laboratory equipment.

Free Literature

(21) EXCAVATORS: *Bucyrus-Erie's* 16-page pocket-size booklet S-21-E, outlines advantages to be derived from individual design in B-E's ⅜ to 4-cu yd excavators. Field photos of each size machine highlight the illustrations.

(22) IMPREGNATOR: Bulletin from *Safe-T-Seal Div.* describes a protective material for motors, switchgear, generators, transformers, insulators; practically all electric and electronic equipment. Safe-T-Seal by means of its "molecutronic" action creates a zone around electrical conductors to neutralize the contact of atmospheric conductive paths.

(23) ROCK BOLTS: Time usually devoted to erecting timbers can be profitably used to boost production. Information is available from *Colorado Fuel & Iron Corp.* on rock bolts, the superior roof and wall support.

(24) COOLER: Get the "inside story" on faster cooling, minimum floor space, and drive power from *Stearns-Roger's* bulletin on the improved calcine cooler. Features include: predetermined cooling, low power requirements, shell protection, and continuous feed.

(25) VENTILATION: For exploration, mining "no fan beats" *Jeffrey's* 5 hp Aerodyne midget for blowing or exhaust through tubing. Easily carried from place to place, this sturdy, self-contained fan has free delivery volume of 6200 cfm, 6.5-in. max static pressure.

(26) ROCK DRILLS: *Atlas Copco* light rock drills fitted with Sandvik Coromant drill steels are changing rivers, driving tunnels, and scooping out mountains. Drilling data shows performance advantage over heavier equipment.

(27) GRINDING: *Mine & Smelter Supply Co.'s* catalog 101A states that "rapid change of mill content is necessary for high efficiency." Incorporated in all Marcy mills, this basic principle "has proved, in hundreds of installations, to give greater output and lower kwh per ton."

(28) 3-D MICROSCOPE: Literature from *Bausch & Lomb Optical Co.* describes the value of three-dimensional microscopes for industrial work and research laboratories. The 38-page brochure has three photographs that can be observed through a viewer that produces a three dimensional depth effect.

(29) FROM NAPTHA TO GRAIN DUST: Booklet B-2402 from *Reliance Electric & Engineering Co.* describes a corrosion-proof ac motor that performs equally well in explosive coke dust or lacquer atmospheres. This motor, which can be vertical or foot-mounted, runs trouble-free in high octane area or salt water spray.

(30) LOW ALLOY STEELS: *International Nickel Co.* has a 48-page booklet illustrating wide application of nickel-copper high strength low alloy steels in mining, transportation, and other fields. Working methods, mechanical properties, compositions, and availability of seven steels of this class are given.

(31) INDUSTRIAL INSTRUMENTS: *Minneapolis-Honeywell Regulator Co.'s* catalog 5002 is a new issue of the composite catalog that briefly and concisely describes industrial instruments and equipment, including latest developments.

(32) VERSATILE TRACTOR-SHOVELS: *Frank G. Hough Co.'s* "Useful Attachments for Payloader Tractor Shovels" illustrates Payloader adaption to many tasks beside bulk materials handling and earthmoving.

(33) GEIGER COUNTER: *Nuclear Measurements Corp.* has developed a portable Geiger counter, weighing 4¼ lb stripped; 4¾ lb with phone and carrying strap. Circuit box is 3x3½x7 in. Model GS-3 is claimed to be easier to service than any comparable Geiger counter.

(34) FEEDERS: *Fuller Co.*, a subsidiary of General American Transportation Co., has a bulletin on roll and vane-type feeders and rotary valves. These feeders, built of cast iron or iron and steel combinations, are designed to handle a variety of dry pulverized and granular materials.

(35) BELT CONVEYOR: *Barber-Greene Co.* has a catalog showing how this company has given "a new meaning to the economy, flexibility, high quality, and utility of belt conveyors."

(36) DIESEL ENGINES: *Ingersoll-Rand*, pioneer in the development of diesel engines since 1918, has a 20-page illustrated bulletin on the type "S" and "SS" heavy duty diesel engines in sizes from 375 to 1000 hp. Details are given on engine housing design, full floating aluminum bearings, large diameter crankshaft, gear-driven auxiliaries and other features.

(37) BETTER METALLURGY: Replace complex collector combinations with Xanthate Z-11. As recommended by *Dow Chemical Co.'s* mining technical service this "powerful general purpose collector can give you better metallurgy at lower cost."

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

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Please send me { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

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61	62	63	Students should write direct to manufacturer.						

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(38) AC MOTORS: *General Electric's* bulletin GEC-1026 presents complete buying information on standard ac fractional and integral horsepower motors in most general use. Included are general and special purpose fractional horsepower motors and fhp gear-motors. Information includes photos, ratings, book prices, dimensions, weights, frame numbers, and standard modifications.

(39) CENTRIFUGAL PUMP: *Dorr-Oliver Inc.* has a 6-page bulletin on the type L centrifugal pump, now available in 1, 1¼, 1½, and 2-in. models. Major design improvement is the high cut-water or tongue of the volute. This makes the unit self-venting, minimizes formation of air pockets, and improves priming characteristics.

(40) REFINERY WASTE: *Proportioneers Inc.*, division of B-I-F Industries Inc., has reprinted "Chemical Flocculation of Refinery Waste" in the form of an applications manual on petroleum refining. This comprehensive 16-page article contains various photographs, diagrams, and tables.

(41) ELECTRIC CONDUCTOR ACCESSORIES: Available from *Reynolds Metals Co.* is a 12-page guide for selecting and installing accessories needed with aluminum wires and cables in the construction of overhead electric transmission and distribution lines. Some 32 illustrations supplement the text.

(42) SINTERING HEARTHS: *The Mace Co.*, fire concentration metallurgists, has a 12-page bulletin on sintering hearths, explaining applications, sizes, capacities and advantages. Also shown are other Mace products, including smelting and cupelling furnaces.

(43) CRUSHING, GRINDING: "The practical approach to maximum efficiency" is *Allis-Chalmers'* new third theory of comminution. This formula together with more than 1200 work indexes is available in a 72-page bulletin.

(44) UNDERGROUND MINING: *Caterpillar's* 12-page booklet "Four Steps to Increased Profits in Underground Mining" shows diesel-powered crawler tractors, motor graders, and rubber tired units in actual mine locations. A section of the pocket-size booklet is also dedicated to Cat diesel electric sets supplying power for compressors, generators, hoists, and other power machinery.

(45) MORE AIR FOR LESS $$: Twelve-page catalog from *Le Roi Div.*, Westinghouse Air Brake Co., pictures all 40 models of portable

type Airmaster compressors available. A quick reference chart easily shows the capacities, engine types, and mountings.

(46) JAW CRUSHERS: Bulletin 5105 shows how *Traylor* HB jaw crushers produce greater capacities using less power per ton produced. Feed openings range from 36x42 in. to 56x72 in. and capacities from 120 to 540 tph.

(47) TOUGH FEEDERS: "AMSCO" feeders, covered in *Stephens-Adamson's* bulletin 255, withstand the punishing impact and abrasion of ore loads—often falling many feet—through multimillion ton service. One unit logged over 26-million tons in a seven-year period, another has handled 65-million tons in 23 years. All wearing parts are made of manganese.

(48) PRODUCTION LOADING: Bulletins L1017A-B-C from *Eimco Corp.* tell how and why production with Eimcos save money. Bulletins, illustrated with diagrams and photographs, contain authoritative articles reprinted from mining magazines.

(49) ROUGHER: *Denver Eqpt. Co.'s* "Sub-A" super rougher, engineered to handle large volumes of pulp with the greatest possible efficiency, is discussed in bulletin F10-B87. The improved suspended shaft assembly in each cell gives maximum efficiency, regardless of the rate of feed, for positive control over agitation and aeration.

(50) JIB/TRACTOR COMBO: By mounting two *Joy* LM-67 drills with 6-ft chain feeds and Hydro drill jibs on a diesel tractor, a uranium mining company made its own Drillmobile and reduced labor costs 80 pct. Bulletin 87-F tells the full story of this new jib-tractor.

(51) INSULATED PIPING: *Ric-wiL Inc.*, world's largest supplier of insulated piping systems, has a 90-page catalog listing illustrations and specifications of insulated piping systems for underground or overhead use.

(52) MAGNETIC SEPARATORS: *Eriez Mfg. Co* has a 24-page booklet on how "magnetic ideas" have been applied with engineering know-how to solve many vexing problems in innumerable industries. Case histories explain how various companies are using permanent, non-electric magnets to prevent iron contamination in their products, protect their machinery from damage by tramp iron, or prevent fires.

(53) V-BELT DRIVES: Bulletin V-215A from *Flexible Steel Lacing Co.* shows Alligator open-end V-belting fasteners and tools for A, B, C, and D drives. These drives, used for emergencies when correct endless V-belt is not available, eliminate costly dismantling.

(54) CONTROL VALVE: Designed primarily for the severe service of solids in suspension—coal slurries, paper pulp, sand, etc.—the *Red Jacket* valve is suitable for other applications. Pressure in an annular space between the valve body and sleeve does the work; as this pressure varies, valve opening varies.

(55) AIR COMPRESSORS: Available in 125 and 150 hp sizes for up to 974 cfm at 125 psi, *Pennsylvania Pump & Compressor Co.'s* air compressors are two-stage, double acting, water-cooled, heavy duty angle type. Noteworthy is the air cushion valve equipment, not only efficient, but unique in the complete absence of bolts or screws.

(56) BRAZING MANUAL: Major brazing methods in joining metals using silver alloys and filler metals, fluxes, and gas atmospheres are shown in *Air Reduction Sales Co.'s* 24-page manual. Subjects discussed include silver brazing procedure, selection of brazing and filler metals, prebraze cleaning, and assembly of brazed joints.

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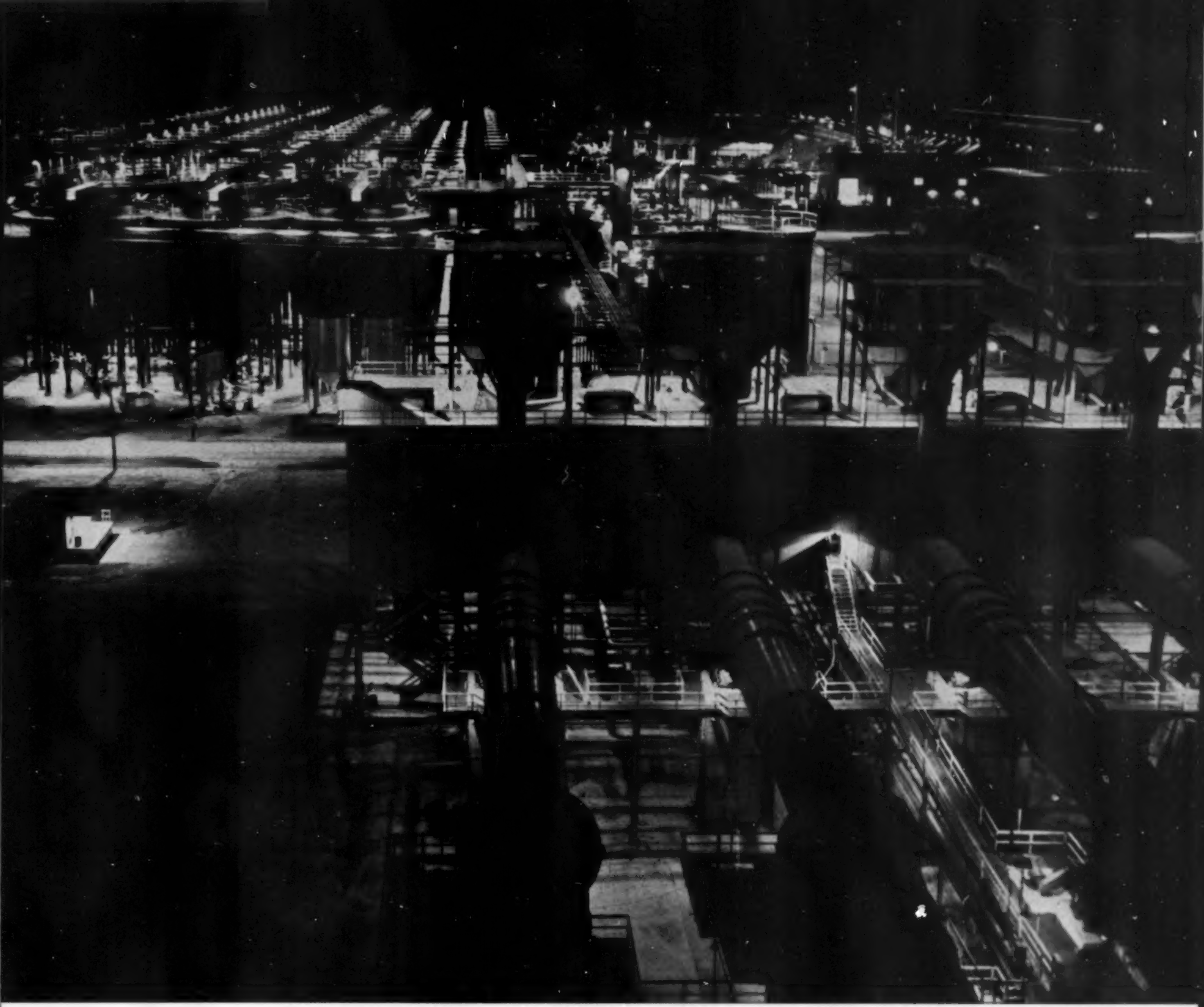

Reynolds Metals Company's La Quinta Alumina Plant Corpus Christi, Texas

Safety Campaign Gathers Speed

More than 342 mines have enrolled in the National Campaign for the Prevention of Fall of Ground Accidents, sponsored by the Mining Section of the National Safety Council. Registrations from Colorado, Michigan, Missouri, Idaho, and Montana are especially large. Nine Canadian provinces are represented with a total enrollment of 95. Fifty mines are in Ontario.

South African Shaft Sinking Record

Some 590 ft of concrete-lined shaft was sunk under full cementation cover recently in a one-month period at the Vaal Reefs mine in the Klerksdorp district of South Africa. The mine is claiming a world record for manually cleaned shaft.

Jones & Laughlin in Canadian Venture

Jones & Laughlin Mining Corp. has signed a rail freight contract with Ontario Northland Ry. A. R. Freeman, general manager of the road, says that the pact indicates J&L's intention of developing iron ore deposits in Boston Township, five miles south of Kirkland Lake, Ont. He also stated that J&L is contemplating construction of a $10 million concentration plant.

AEC to Sign Mill Construction Pact

Grand Junction office of the Atomic Energy Commission Raw Materials Div. announced that a contract will be signed with Mines Development Inc. for construction and operation of a mill to process uranium at Edgemont, S. D. Mines Development will finance construction and operation. The proposal of a mill at Edgemont was one of several under consideration. Construction is scheduled to start immediately after contract signing.

Canadian Iron Ore Discovery Optioned

Steel Co. of Canada and Pickands, Mather Co. of Cleveland announced joint optioning of a new iron ore discovery north of Kapuskasing for a total of $1 million if options are exercised. Drilling on two anomalies are reported to have shown magnetite ore which can be concentrated to shipping grade.

No Proof of Lung Cancer in Uranium Mines

Five years research on the hazards in uranium mines of the Colorado Plateau has resulted in no conclusive proofs that the internal alpha radiation, ever-present in those mines, causes lung cancer. This was reported by J. D. Torrey, industrial hygienist, and P. W. Jacoe, chief of the Environmental Health Services of the Colorado State Dept. of Health, at a meeting of the American Conference of Governmental Industrial Hygienists.

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CRUSHER

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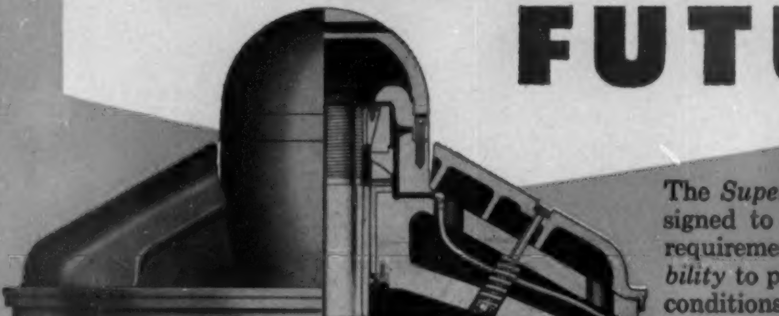

The *Superior* crusher you install today is designed to meet your specific and immediate requirements — and it also has *built-in flexibility* to permit adaptation to future operating conditions.

Complete Adaptability

Changing the eccentric throw, crusher speed or shape of crushing chamber, varies capacity and product size. This high degree of flexibility enables you to obtain the best possible crusher operation to suit other plant equipment.

For additional flexibility, the *Superior* crusher can be fitted with *Hydroset* mechanism, a hydraulic arrangement for raising or lowering main shaft and mantle. This control facilitates emptying the crushing chamber in case of power failure or other emergencies. It also compensates for wear on concave and mantle and, when required, makes it possible for you to change product size instantly.

Write for Bulletin 07B7870

This 32-page bulletin describes the *Superior* crusher and gives you valuable crushing data. It's a book you'll want to have and keep. Ask your A-C representative for a copy or write Allis-Chalmers, Milwaukee 1, Wis.

A-4655

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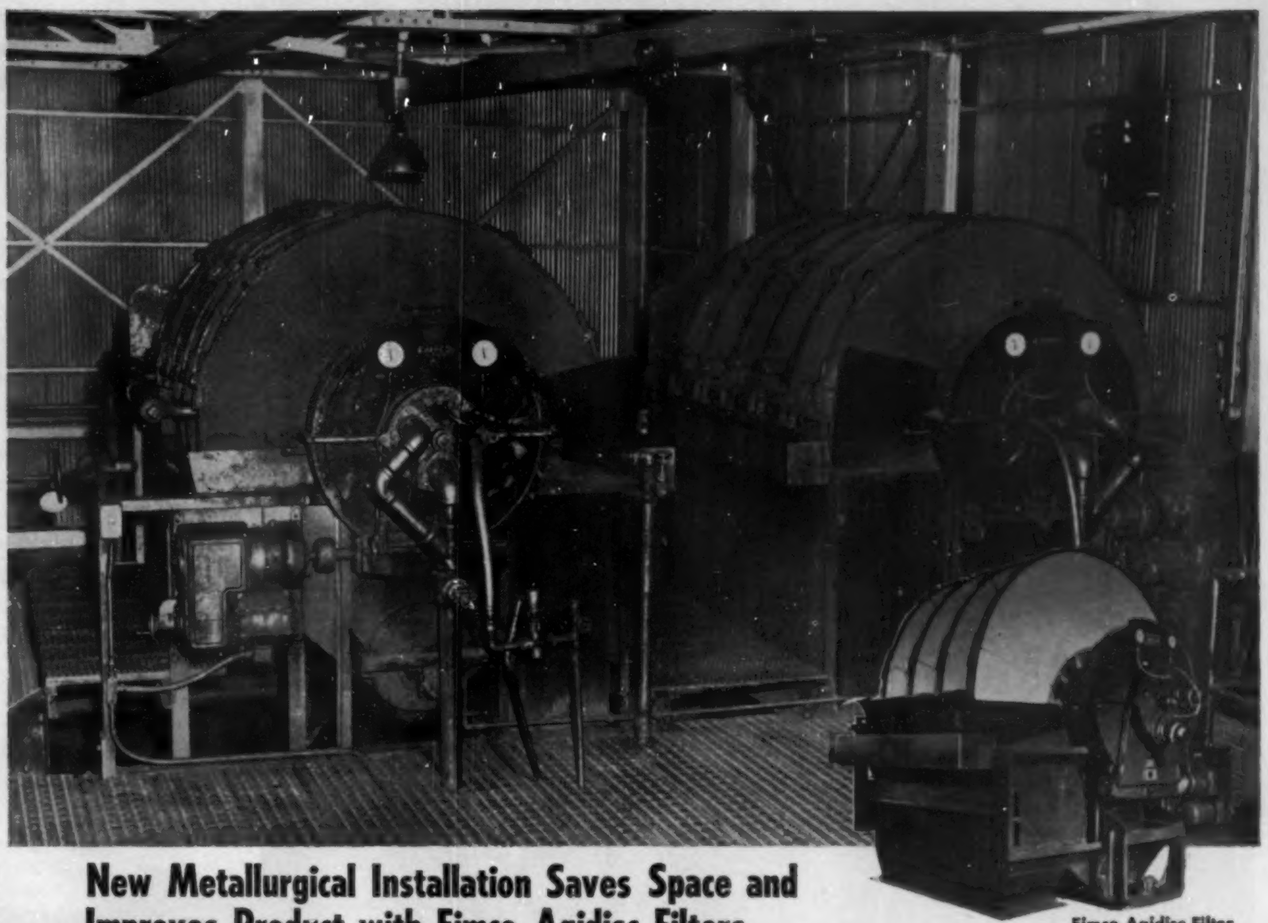

Eimco Agidisc Filter

New Metallurgical Installation Saves Space and Improves Product with Eimco Agidisc Filters

The photo above shows an installation of two 6' diameter by 5 disc Eimco Agidisc Filters in their operating position in a new metallurgical concentrating plunt.

These filters were installed as a result of the owner company and Eimco cooperation in a joint effort to improve the operation of the filter station at this plant and reduce moistures with the most economical equipment.

After the installation had been operating for six months the following data was made available.

	PREVIOUS EQUIPMENT	NEW EIMCO FILTERS
1. Concentrate handled	350,000 lbs./24 hrs.	350,000 lbs./24 hrs.
2. Labor required	1 man full time	1 man part time
3. Attention required	Constant inspection	Periodical inspection every 6-8 hrs.
4. Operating Capacity	Full load—no capacity for additional tonnage	½-¾ load—capacity for 33% to 100% additional tonnage
5. Equipment	4—Drum filters (not Eimco)	2—6' dia. x 5 disc Eimco Agidiscs
6. Filter area	621 sq. ft.	500 sq. ft.
7. Floor Space occupied	416 sq. ft. filters only	189 sq. ft. filters only
8. Cake Moisture	20%—21%	14%—15%
9. % Moisture reduction over previous method		33%
10. Filter rate increase over previous method		more than 15%

Eimco specializes in equipment to do a better job in filtration. Before you buy, take advantage of Eimco's experience in building filtration equipment for customers who look beyond first cost to get quality construction, individual design and guaranteed performance.

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B-102

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INCO Unveils Oxygen Flash Smelting Process

This is the south end of Inco's 1000-ton flash furnace showing burner platform. Feed pipes extend from the burners up to rotary air locks. Oxygen lines with their swivel joints are shown connected to the burners.

International Nickel Co. has revealed details of its oxygen flash smelting process for treating copper concentrates. One of the world's first commercially successful processes for smelting fine sulphides in suspension, the method developed by Inco is now being used to treat all of its copper sulphide concentrates.

The company in 1954 delivered more than 250 million lb of refined copper. Under development since 1945, the process recently completed its first full year of successful operation. In addition to reducing smelting costs, the use of oxygen for smelting has resulted in production of a high quality furnace gas from which liquid sulphur dioxide and sulphuric acid are made.

Process details were formally revealed for the first time in a paper presented by C. E. Young of the smelter operating staff. Essentials of the method were first given in MINING ENGINEERING, in a news story in the April 1954 issue. The current report was prepared by the Inco Mining & Smelting Div. staff, and read at the annual meeting of the Canadian Institute of Mining and Metallurgy.

Cooperating with Inco in the flash smelting technique were Canadian Industries (1954) Ltd. and the Canadian Liquid Air Co. Ltd. The process eliminates fuel normally required for smelting and permits large-scale production by Canadian Industries Ltd. of liquid sulphur dioxide produced from the flash smelting furnace gases.

Low-cost oxygen for the process is produced by the Oxyton, built for Inco by Canadian Liquid Air. The unit produces 325 tons of 95 pct pure oxygen every 24 hr, corresponding to 2 2/3 billion cu ft of oxygen per year, or three times the production of all the cylinder oxygen plants in Canada.

In the Inco process, finely divided copper concentrates and flux are dried and injected with oxygen into the preheated smelting furnace to produce matte, slag, and a gas containing about 75 pct sulphur dioxide. In the furnace, the oxygen combines with some of the sulphur and iron of the chalcopyrite to form sulphur dioxide and iron oxide. Heat of the reaction is enough to melt the residual copper-iron sulphide to form a matte, and the iron oxide combines with siliceous flux to form a slag.

An outstanding feature of the process is the cleaning of the copper-rich slag by flash smelting pyrrhotite at the skimming end of the furnace. Slag is showered with iron sulphide droplets which, in settling into the matte beneath, extract copper from the slag.

Gas is water scrubbed and treated by a wet Cottrell before conversion into liquid sulphur dioxide. Production of liquid sulphur dioxide involves drying the cleaned gas with sulphuric acid, then compressing and cooling the gas to condense the sulphur dioxide.

Inco's flash smelting furnace is 68 ft long, 24 ft wide, and 17 ft high at the ends, outside its steel casing. Smelting capacity is about 1000 tpd of dry solid charge.

June issue of MINING ENGINEERING will carry a complete and exclusive story of the Inco Flash Smelting Process by C. E. Young.

Freeport, Pittsburgh Consolidation to Mine Potash

Freeport Sulphur Co. and Pittsburgh Consolidation Coal Co. jointly announced the formation of a company to produce potash from a mine to be developed in New Mexico's Permian basin.

The new firm, National Potash Co., has taken over potassium leases awarded Freeport by the Dept. of the Interior on 12,775 acres. It has also taken over federal permits and state leases on additional acreage. Richard C. Wells, Freeport vice president and controller, will be president of National Potash. Thomas G. Ferguson, formerly vice president of one of Pittsburgh Consolidation's divisions, will be operating vice president of the new company.

Capital outlay for mine, plant, and related facilities has been estimated at $19 million. National Potash has arranged to borrow $12.5 million from an insurance company. Freeport and Pittsburgh Consolidation will each supply half of the remaining capital requirements.

Facilities will be designed to produce potash containing the equivalent of about 250,000 tons of potassium oxide per year. Freeport discovered the deposit in exploratory drilling started in 1949. Some 60 core tests, involving more than 100,000 ft of drilling, have been completed. About two years will be needed to sink shafts, build a refinery and related equipment, and install a 21-mile water pipeline. Production has been scheduled to start in 1957.

Pittsburgh Consolidation produced more than 22.5 million tons of coal last year from its wholly owned or associated mines in West Virginia, Kentucky, Ohio, and Pennsylvania. Freeport, in addition to producing sulphur in Louisiana and Texas, is operating oil wells in four states. Included among its interests in other minerals is a nickel project in Cuba near Moa Bay.

The area in which National Potash will conduct its operations in New Mexico is about 32 miles east of Carlsbad on the Lea and Eddy county line.

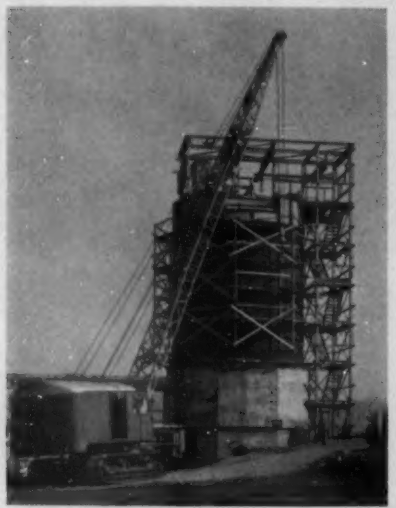
March MINING ENGINEERING, the Annual Review issue, noted that the National Potash development will have the second Koepe hoist installation made in the U. S. The National Farmers Union and Kerr-McGee Oil Industries have also formed a new corporation to develop holdings in the Permian Basin area.

New Jersey Zinc Rejuvenates Sterling Zinc Producer

Company Completes Its Deepest Shaft

For more than half a century New Jersey Zinc Co.'s Sterling mine at Ogdensburg, N. J., has been one of the most important zinc operations in the country. Now, it's getting a face lifting.

Sterling's new shaft, 2700 ft and the deepest one of any at the company's properties, has been completed. With the new shaft is a just completed 100-ft steel headframe. The ore hoist, driven by two 450 hp motors, will deliver ore to the surface for processing.



The ore crushing plant was erected with the aid of a Caterpillar-powered Northwest crane equipped with an 85-ft boom. New practice eliminates milling ore into concentrates.

New shaft and headframe have already been completed as part of the Sterling mine modernization program. The shaft, 2700 ft, is the deepest of any of the company's operations.

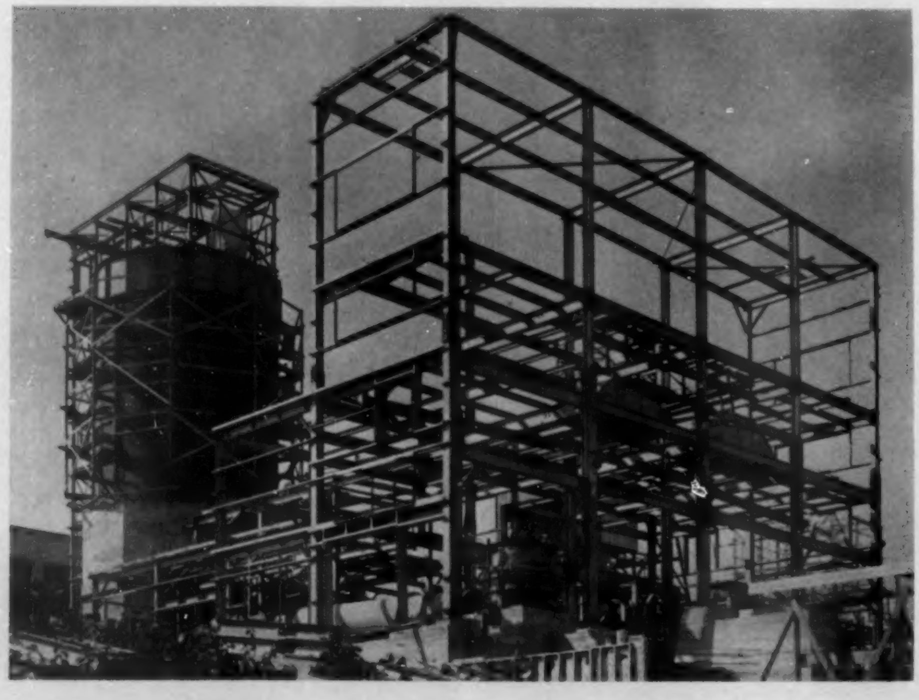
A major processing change will eliminate milling crude ore into concentrates. New crushing and grinding equipment will have to be installed both underground and on the surface. Ore will be shipped directly to the Palmerton, Pa., smelter. The company announced that a method has been developed for producing an intermediate product suitable for use on mechanical grate oxide furnaces from Sterling crude ore.

When the modernization project is finished, Sterling will have in addition to the new shaft, a new crushing plant, a conveyor system, equipment for ore shipping, and a variety of other improved facilities. The mine is more than a century old. Modernization means that many of the old facilities will be abandoned.

Sterling is being modernized along with other New Jersey Zinc operations in Pennsylvania, Virginia, Tennessee, Colorado, and New Mexico. The Sterling redevelopment will not be completed before the end of 1955, according to the company. However, increased production was achieved in the last quarter of 1954 and additional increases are scheduled for this year.

Four 2000-cfm air compressors have been installed and will furnish compressed air to all parts of the mine for operation of rock drills and other equipment. A modern shops building has been constructed and locomotives and mine cars of the latest design are going into operation.

New Jersey Zinc spent some \$3.6 million last year for additions and improvements to mines, manufacturing facilities, and other properties. A total of \$36.6 million has been invested since 1948 in modernization and expansion of production facilities. At the close of 1954, the company's net current assets were \$26,086,982. In addition it owned Government bonds and other securities carried at \$21,960,273 and notes receivable of \$1,324,000, for a total of \$49,371,255.

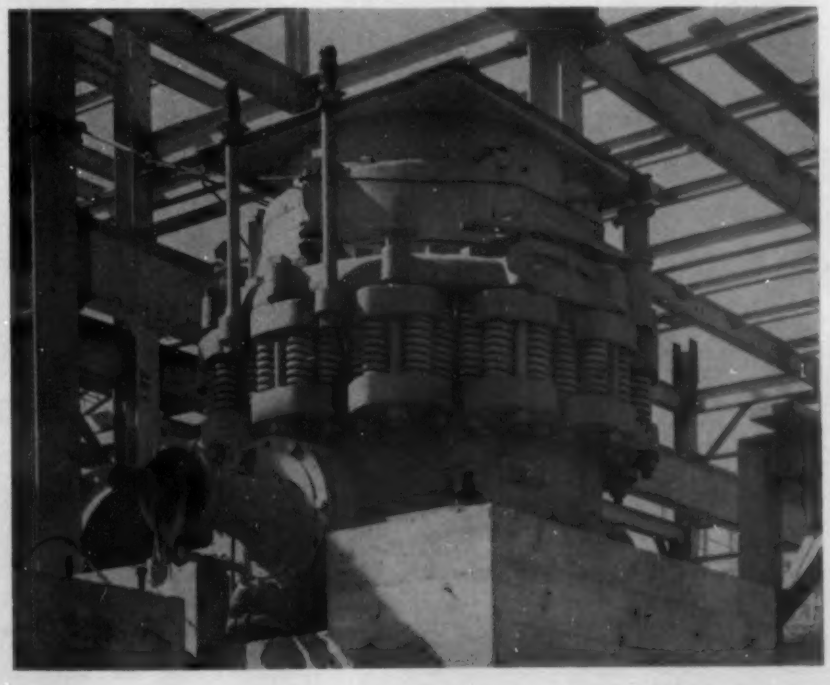


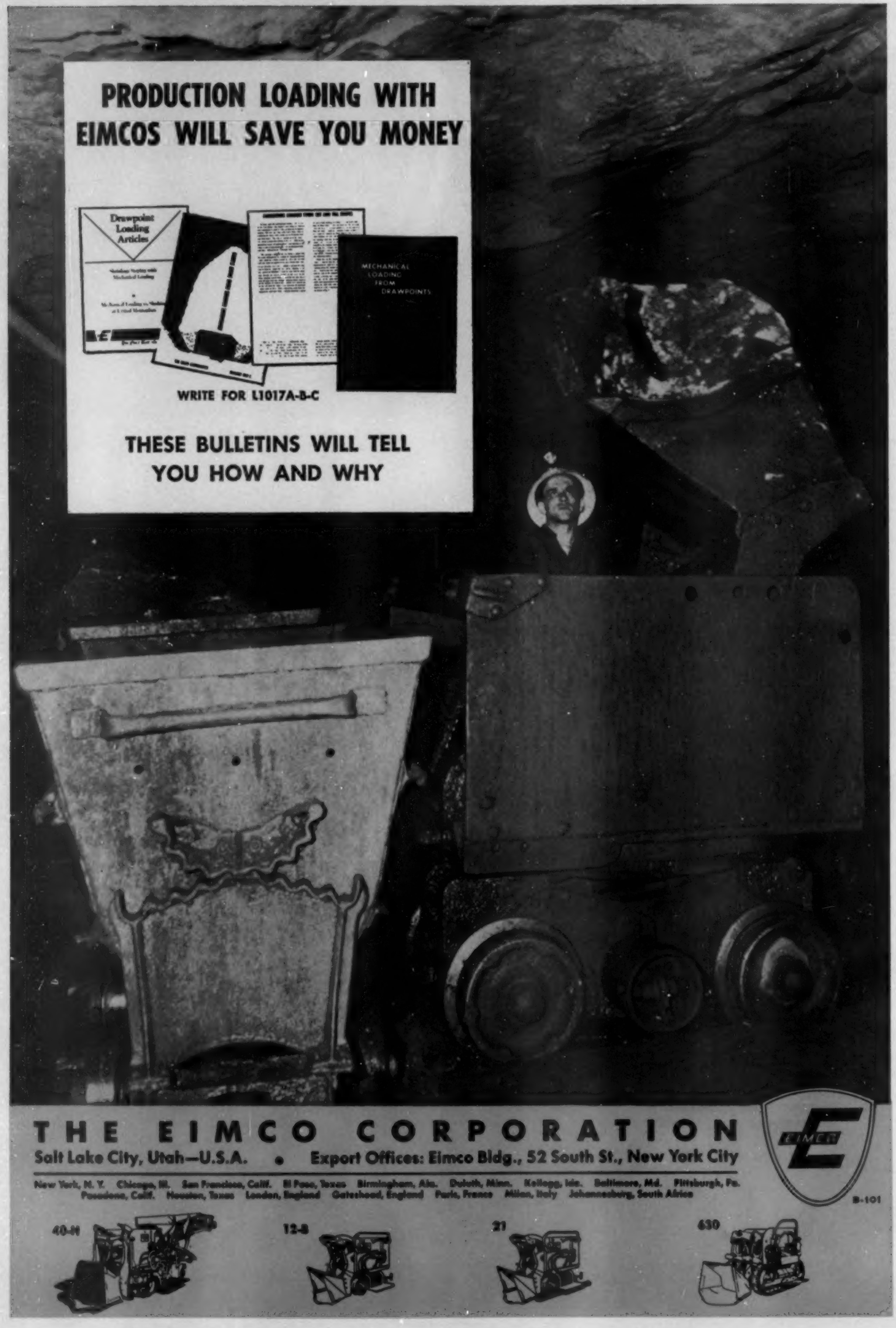
Crushed ore from the mine goes to the bin at left. From there it proceeds to the drier in the center and then to the fine crusher. A conveyor system to be built will transport ore to shipping point. Fine crusher is seen in foreground.

Sterling mine haulage efficiency is expected to get a big boost from new mine cars and locomotives that are part of the equipment being installed in the mine. New life is being injected into the century old zinc mine.

When this picture was taken the shop buildings awaited only finishing touches. Along with new production equipment, New Jersey Zinc is installing the latest in maintenance tools to keep the mine at peak performance.

This 1954 model Symons crusher will grind Sterling zinc ores to the size needed for smelting. With the new processing plans, many of the old facilities at the mine are being abandoned as new equipment goes to work.





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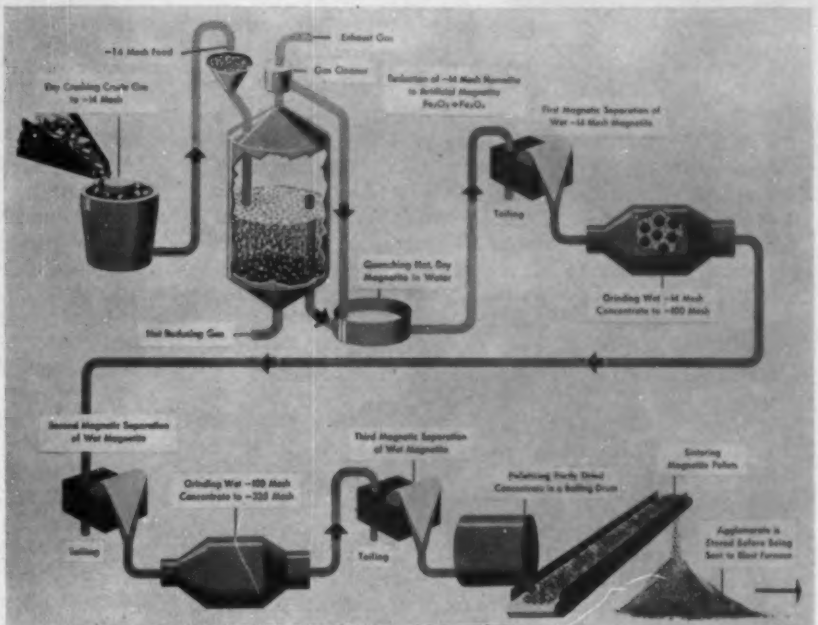
Jones & Laughlin Successful on Nonmagnetic Ores

Pilot Plant Produces Usable Concentrate



Schematic drawing of pilot plant for processing Michigan low-grade iron ore at Jones & Laughlin Steel Corporation's Ore Research Laboratory, Negaunee, Michigan.

Jones & Laughlin Steel Corp.'s ore research laboratory at Negaunee, Mich., is operating what is believed by the company to be the first pilot plant demonstration that Michigan nonmagnetic ores can be rendered magnetic and then concentrated by magnetic separation.

The work tentatively makes available a large "new" reserve of iron ore based on the knowledge that large deposits of nonmagnetic taconites containing about 30 pct iron exist in the U. S. The continuous process pilot plant at Negaunee is designed to upgrade nonmagnetic ores to a concentrate containing as much as 63 pct iron. Slightly more than two tons of Michigan crude taconite have been needed to produce one ton of concentrate.

Magnetic conversion of the hard, quartz-bearing rock in which iron oxide or hematite is distributed as a fine-grained mineral is provided by a new type of fluidized solids reactor. The reactor is already in commercial use, but primarily for roasting sulphide ores. In the J&L plant, a small-scale model of the reactor is operated on the same principle as the catalytic cracking reactors used in petroleum refining.

Nonmagnetic Michigan taconite, ground to —14 mesh particle size, is chemically reduced to magnetite while suspended in a turbulent stream of hot reducing gas. Accurate temperature control and uniformity of reaction is maintained by the intimate contact of gas with the taconite particles in turbulent motion.

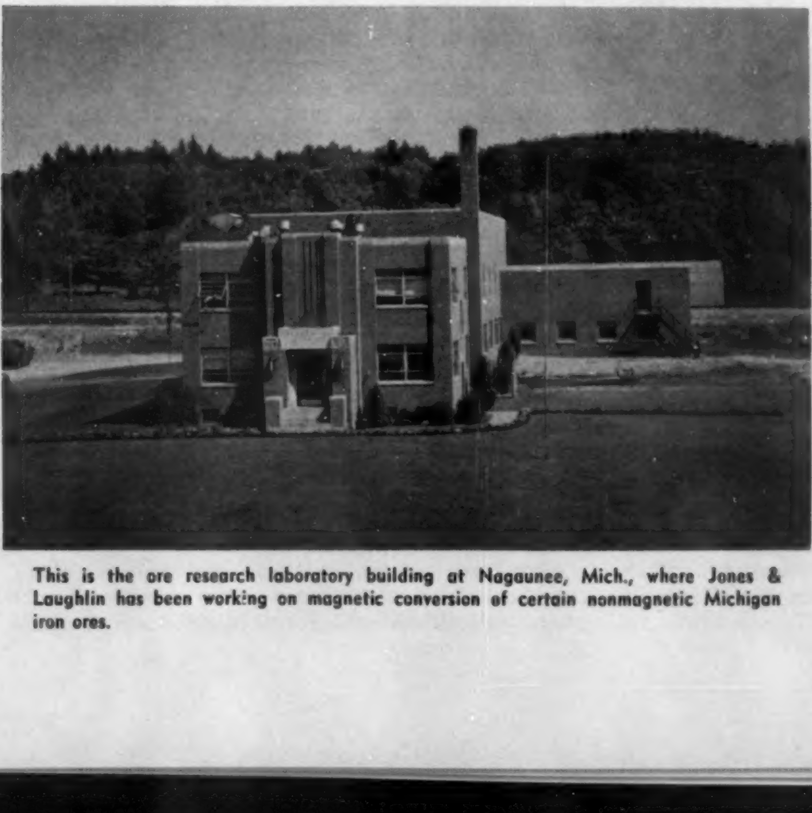
After leaving the furnace the hot ore is quenched in water. This shock-cooling produces cracks in the ore which facilitate fine-grinding and better separation of iron mineral from the silica after grinding.

After three successive grinding and magnetic separation stages, the ore is concentrated to a high grade fraction containing as much as 63 pct iron. Half the original ore is eliminated as high silica waste.

During the initial concentration step the —14 mesh ore enters a wet magnetic separator where some 20 pct of the material is removed as tailing. Another 20 pct of the original ore is removed in the second step. The rough concentrate from the first operation is ground to —100 mesh and subjected to a second magnetic separation process.

In the last phase, the concentrate remaining, about 60 pct by weight of the feed to the plant, is further ground to —325 mesh and treated magnetically to eliminate more nonmagnetic material.

Wet grinding operations are performed in two successive ball mills. Each mill operates in conjunction with a classifier. The classifier takes the grinding mill discharge and separates the material fine enough for the magnetic separators.



This is the ore research laboratory building at Nagaunee, Mich., where Jones & Laughlin has been working on magnetic conversion of certain nonmagnetic Michigan iron ores.

Final Concentrate

Water is removed in thickening tanks by drum filters extracting fluid by vacuum pumps, after completion of concentration. The final concentrate is too fine for direct blast furnace use and cannot be sintered directly by conventional means. To prepare a suitably coarse feed for sintering, J&L has applied pelletizing as the initial agglomeration process. A rotary drum forms the concentrate powder into balls or pellets which can be hardened on the moving grate of a sintering machine. At the same time, the sintering machine consolidates the individual pellets into grape-like clusters. F. X. Tartaron, manager, ore research, is the supervisor of the staff at Negaunee responsible for the project.

J&L has a backlog of know-how in low grade iron ore beneficiation at its Adirondack martite operation at Benson Mines, N. Y.

TAXATION, piracy, natural depletion, and a host of other causes are ruining the mining industry, according to numerous persons whose judgments appear in the public prints. Once in a while someone comes out and says something nice, something hopeful, and something cheerful. Recently, statements of the latter type emanated from two widely separated sources—Florida and Michigan.

In Michigan, the Society of Industrial Realtors published a report on the state's mineral situation. They found that iron and copper ore reserves are sufficient for a long period of mining in the Upper Peninsula. The report contends that intensive beneficiation research on low grade iron ores has led to production from such plants, with another plant to be ready within a year.

As for copper, the report states: "The White Pine Copper Co. is investing in excess of $70 million in a large and ultramodern mining operation in Ontonagon County. Calumet & Hecla Inc. . . . is now engaged in reopening closed mines from which a yield of 14 million lb of copper per year is expected."

The report goes on: "A mineral ores research building is now under construction by the Michigan College of Mining and Technology. When completed, the research program undertaken will be of great assistance in the field of low grade ore development for mining and processing purposes."

The future of the Upper Peninsula exists in the utilization of the area's natural resources of forest products, farm crops, and minerals. Upper Peninsula workers show a high individual productivity—as much as 10 to 15 pct above that of other areas.

In Florida, Louis Ware, president of International Minerals & Chemical Corp., speaking at a joint meeting of civic and service clubs in Bartow, said: "The real usefulness of this great industry [phosphate mining] is the phosphate which is shipped from here all over the country and all over the world to supply fertilizers and chemicals that are so necessary and add so much to the productivity wherever used."

He was of the opinion that there was no resource that is more important. "However, taken in the raw, it is just a rock on the ground and it requires the capital of the investors, the ingenuity of management and technical people, and the capital and workmen, such as we have in this community, to make it a thing of value."

Mr. Ware noted the change that has taken place in recent years in the fertilizer business. "I refer to the demand that has developed for high analysis goods rich in phosphorus, nitrogen, and potash. Farmers are learning to use this more expensive product which carries a greater percentage of nutrients for plant food, and have learned its economy."

The result, he said, has been the construction of a number of large triple superphosphate plants which make other products as well. About $60 million worth of new plants have been built in the Bartow area.

Uranium production from International Minerals & Chemical's plant at Bartow came in for its share of comment.

"You have heard a lot about uranium production at our plant, and the possibilities of uranium from the phosphate deposits. I think there has been a lot of careless talk. However, anyone can speak up and give his opinion because no one knows. It is certainly true that none of us will find uranium a bonanza in the foreseeable future, and the plants we have built will show only very modest profits, we believe, and return of the investment over ten years or so."

Mr. Ware also noted that his firm has been working on extracting fluorine from material in process, but difficulties remain. He believes that in time a method will be found, but could not say when. A gas scrubber is currently being installed in line with fluorine extraction experiments.

HOW does an industry get stability, providing one accepts something resembling that state is possible in these or any other times? While Harry Moses, president, Bituminous Coal Operators' Assn., is not "naive enough to believe that the country has seen its last major strike," he sees a clearly defined road leading to the objective.

Mr. Moses traces the birth of the current era of labor peace in the bituminous coal mines to 1949, when a small group of operators did some "long-range thinking." For one thing, they realized that the three-ring circus attendant on most so-called bargaining sessions were no more than "kleig-lighted" free-for-alls. Labor leaders and management alike made "speeches" too often reeking with half-truths and vilifications. Newspapers and newsreels found the copy that made sensational reading and viewing. It served nothing more than to "warm up the parties for a good fight." Sometimes the fight didn't come off, but more and more customers who were afraid of coal shortages stopped using coal.

Speaking at the College of Commerce of West Virginia University, Mr. Moses also pointed out that Government intervention served only for "settlement of . . . economic problems on a political basis."

The first step toward removing coal negotiations from the aura of politics, name calling, and knock-down, dragout brawling was the formation of the Bituminous Coal Operators' Assn., representing about half the tonnage of the bituminous coal mining industry. The old, fruitless joint wage conferences were discarded in favor of intra-industry conferences and direct collective bargaining between John L. Lewis and Mr. Moses.

Both men had instructions from their members. They came together after many meetings with policy committees which continued during negoti-

ations. The business at hand was attacked without speechmaking. "Adoption of this new philosophy and this new mechanism by both management and the union is giving the American public a minimum of five years of almost uninterrupted coal production, unparalleled in modern times."

Another factor contributing to the peace of the adoption of the open-end contract. The fixed termination dates of the old contracts appeared to act as a time bomb. When the contract expired—bang.

"The third significant characteristic of our new relationship is that the establishment of an industry organization has made possible swift and effective handling of national problems on an authoritative basis that has resulted in greater cooperation and understanding." An example of cooperation on a joint problem was the working out of an agreement upon a reasonable and modern Federal Mine Safety Code.

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FLOYD B. ODLUM may be asking himself that fabled question "How does my garden grow." But unlike Mary, Mary, quite contrary, it is not with "silver bells and cockle shells, and pretty maids all in a row." His garden seems to be sprouting uranium, uranium, uranium. Federal Uranium Corp., organized by Mr. Odlum and capitalized at a reported 7.8 million shares at 50¢ par, may be the first bonafide, 24 carat, for real, uranium empire. At least, that seems to be the talk around Salt Lake City, where Mr. Odlum's activities have kept the market hopping and tongues going. Six firms have been merged with Federal Uranium. Mr. Odlum's connection with Federal is mildly indirect. Federal is owned by the W. L. Davidson syndicate of Albuquerque, N. M., controlled by the New York financial figure.

The merger is expected to result in the largest uranium firm in the U. S. from the standpoint of claim ownership and indicated and proven reserves. In addition to the original Federal Uranium, the combination now includes U&I Uranium Inc., Interstate Uranium Inc., Western States Uranium Inc., Howell Mining Co., Kentucky-Utah Mining Co., and Utida Uranium Co. All of the companies with the exception of Utida and U&I are Utah corporations. These two are in Idaho.

The merger, according to one report, is only the beginning in series of such moves. One Salt Lake City newspaperman states that the company is interested in almost any uranium claim—even the so-called penny stock deals—that can show proof of mineable ore. Along with approval by stockholders allowing Davidson to take over stock control of Federated Uranium, a resolution was also approved to reduce the number of outstanding shares on a 25 to 1 basis, from 8 million to 320,000 shares of new stock having a market value of about $3.75 per share.

Davidson received about 4,338,000 shares of new stock, or 28 pct of the total. In exchange the syndicate transferred to Federal between 600 and 700 mining claims in Colorado, Utah, Arizona, and Canada. The syndicate also threw in about $170,000 in cash and a commitment to do about $50,000 worth of drilling. Among the properties transferred was the Jacob's Chair group in Monument Valley. The operation has four channels of exposed ore and enough reserves for a "substantial shipping program."

The corporation now owns extensive claims in the Canadian Beaverlodge area through purchase of all outstanding shares of Great Northern Uranium Exploration Co., a British Columbia firm. Price of the shares was 125,000 shares of Federal's new stock. It is reported that Great Northern's 1,015,000 issued shares were closely held.

Atlas Uranium interests, direct and indirect, just seem to keep on growing like Topsy. The latest report from Floyd Odlum is the purchase of $1,265,625 worth of the treasury stock of Northern Australia Uranium Co. The Down Under firm has a Government lease giving it prospecting rights on an area of about 700 sq miles in the Alligator River district of northern Australia, near Darwin.

While prospecting has been on a limited scale, Atlas Corp. says some important uranium orebodies have already been uncovered. Stock will be acquired at 5 shillings per share, its fully paid par value, the price the stock was offered at when the company was formed in 1954. Sydney market value of the stock is currently 10 shillings per share.

The Atlas purchase will provide funds for further development of the prospecting area. Atlas also states that a mill will be constructed when development work is completed. The mill at Rum Jungle, the nearest at present, is some 140 miles away. Part of the distance is over rough country. Technical representatives from Atlas will go to Australia soon for investigations to be completed by mid-June. Australia's uranium setup is similar to that of Canada, with the Australian Atomic Energy Commission authorized to contract for ore and concentrates at a fixed price until 1962.

One question the experts are asking is what has this got to do with Mr. Odlum's "special situations" philosophy. It is usual for the Atlas Corp. to take control of sick, hungry, and generally sad-looking enterprises, build them up, and then get out somewhere before the full potential of the company has been reached. Basically, Atlas is not interested in tying up its funds over a long pull in a few companies.

Atlas and Mr. Odlum are getting their feet wet in the uranium sea with a vengeance. The first big move was the 100 pct acquisition of the Hidden Splendor mine discovered by Vernon Pick. Later, Portuguese and Argentinian moves started to germinate. Floyd Odlum has been tossing big parties all his active life. This may turn out to be his biggest.

Tailings Handling Made Easy

Closeup of 275 ft. dia. Dorr Thickener during final stages of construction. Part of Hydroseparator is visible behind walkway.

7450 TPD of copper tailings can be a big headache without proper disposal facilities. At a new Concentrator in Arizona the proven Dorr Hydroseparator-Thickener team is taking shock loads and variable feed characteristics in stride.

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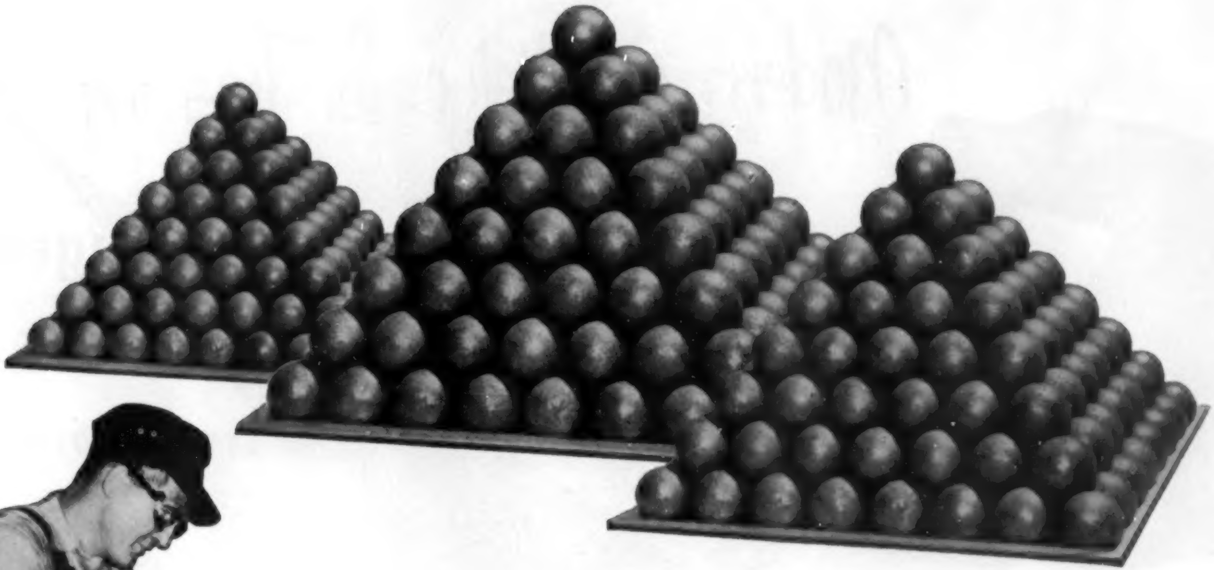

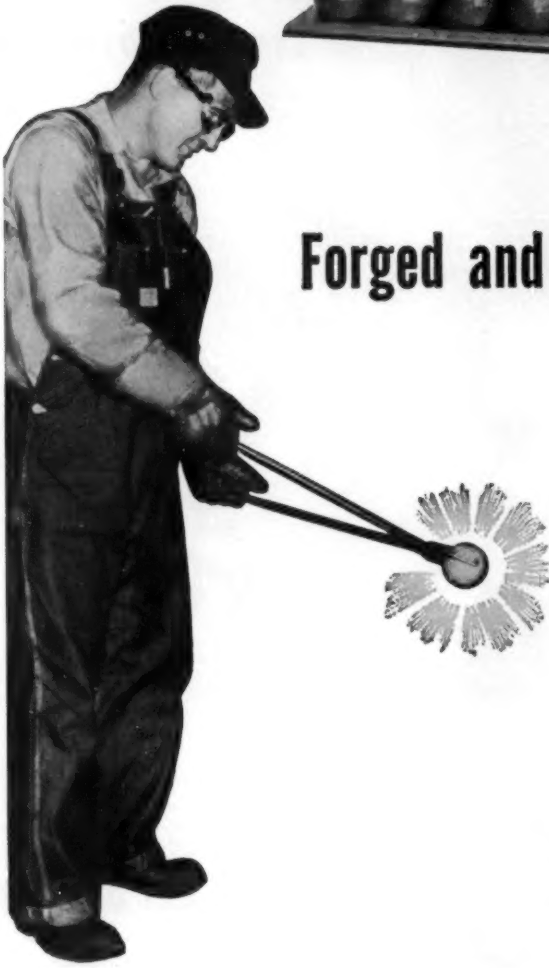

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COPPER-MOLY	Copper concentrates produced from chalcocite with AEROFLOAT ® Promoter average 22% from a feed averaging under 1% Cu. Copper concentrates contain 0.2 to 0.3 MoS_2, from which an 85-90% MoS_2 final product is made by this unique procedure: Depress Cu with Cyanamid sodium ferrocyanide and sulfuric acid in a series of Mo flotation steps to produce a 50-70% MoS_2 product. Regrind. Refloat moly in presence of sodium cyanide to make 85-90% MoS_2 concentrate. (U.S. Patent 2,664,199).
PHOSPHATE ROCK	At Cyanamid's Florida operations, phosphate rock and quartz are floated with crude tall oil (AERO* Promoter 708). Rougher concentrates are washed with sulfuric acid to remove adhering fatty acid. Quartz is then floated off with AEROMINE ® 2026 Promoter and kerosene. Final product runs only three to four percent insol and well over 70% bone phosphate of lime. AEROMINE ® 2026 Promoter is a recent product of extensive Cyanamid research.
LOW-IRON GLASS SAND	Froth flotation now converts dune sand into valuable, custom-built products. Raw sands, comprising equal parts of quartz and high-alumina minerals, average 0.12 to 0.15% Fe_2O_3 and 11.5% Al_2O_3. Scrubbed in attrition machines, these sands are then deslimed, conditioned and iron-bearing minerals floated, leaving behind 95% of the feed in a finished product that assays 0.06% Fe_2O_3 and 10.7% Al_2O_3. Flotation reagents used include sulfuric acid to adjust pH during conditioning to 2.5, pine oil, fuel oil, and Cyanamid AERO* Promoters 801 and 825. Subsequent flotation in another section produces a high-grade feldspar concentrate and a practically-pure quartz tailing. Tailor-made blended quartz-feldspar products are also produced.
ILMENITE	Apatite-ilmenite ore in an amphibole-pyroxene-silicate and clay gangue is crushed, ground and run through Humphreys spirals. Middlings and concentrates are completely deslimed, conditioned at 70% solids with AERO* Promoter 710 and a bulk apatite-ilmenite concentrate is floated off. Bulk concentrate is dewatered and conditioned for apatite flotation at 70% solids and 90° F with caustic starch and AERO* Promoter 708. Separation of apatite from ilmenite is 99.97% complete.

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**THE D9—
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THE American male in his most recent attempt to show that pioneer blood still courses through his veins, i.e., the Do-It-Yourself movement, may be unwittingly undermining the very system which has given birth to the cult's basic weapon—the ¼-in. drill. Whether ego, economic, or recreational motivations are behind the desire to do-it-yourself, financial writers are saying that the cult is endangering the principle of division of labor.

If, they warn, the trend continues and painters, plumbers, carpenters, masons, etc., are bypassed in favor of one's own inner resources—one may find oneself stuck with one's own little talents. People will start doing their own advertising campaigns, do-it-yourself kits will furnish everything needed to make I beams, and so on. At the recent Do-It-Yourself Show in New York City, one enterprising bank took exhibit space and emphasized How-To-Finance purchase of equipment and materials, and general home improvements—without so much as driving one nail. Doing it yourself can be fun, save money, and give a man a sense of achievement—and it can also drive him down to a 98-lb weakling.

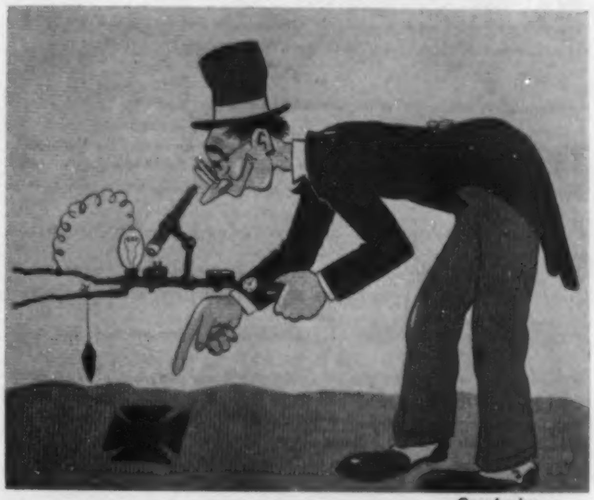
But, we claim no tried and true solution. The simplest way may be to look carefully to make sure that the local artisans are off fishing—or better, safely in bed—and then paint, replace the washer, or hammer like mad. (M.A.M.)

TECHNICAL books published in recent years have leaned toward the more scientific aspects of the various professions and away from the operating man's viewpoint. An exception to this trend is *Moving the Earth* by H. L. Nichols, Jr. (North Castle Books). In fact this hefty volume is a revelation to the user of excavating equipment of any type or size.

Many years back, the old *kink* book was a common item among the belongings of the miner, construction man, or even the flour miller. In a world striving to answer all questions with formulas, this type of literature has disappeared. The trend has been instigated by the demands of the hour, but in the midst of the scientific swing, this 1280-page document arises to help the man operating equipment not governed completely by mathematical data.

The 21 chapters with more than 1200 illustrations include information on land clearing, stuck machinery, ditching and dewatering, underground digging, and pit operation. These are but a few of the subjects covered, and the interesting part is that the chapters describe in detail each phase mentioned. This, as we all know, is rarely the case in modern publications. Quite frequently, the chapter title is more an indication of what the author would like to have explained to the reader than of the actual content.

The author of this new publication is a man of long experience in the construction field, particularly excavation of earth and rock. In *Moving the Earth,* he has given a clear and simple outline of the economical use of excavating machines. Simple remedies for the inherent weaknesses of the apparatus are given proper consideration. The book is a refreshing approach to the problems encountered by this segment of the mineral industry.

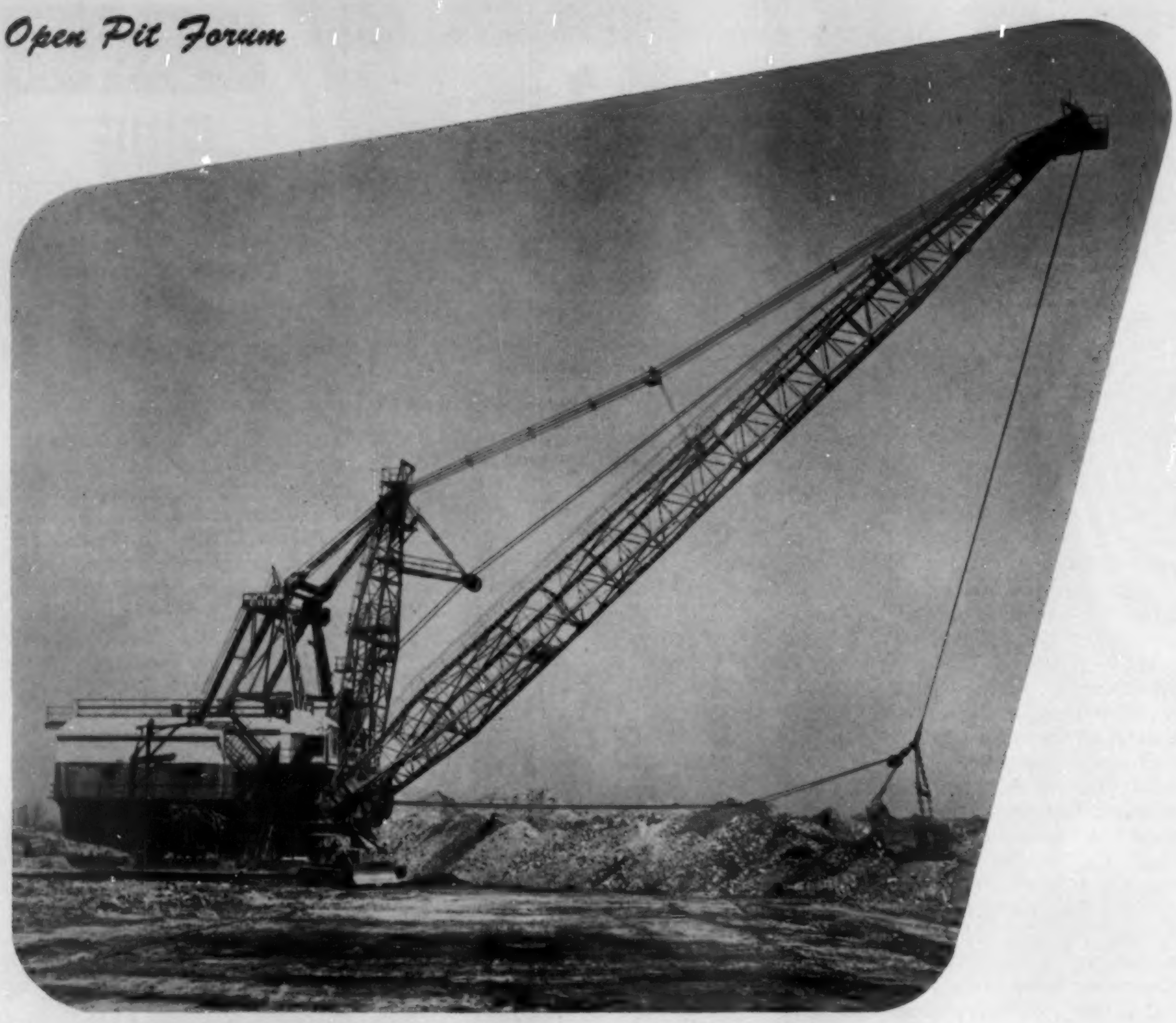


—Geophysics

"The Doodlebugger"

MANY newspapers, books, press releases, and other forms of printed matter pass across our desk. Some are periodicals published at regular intervals and some are what we prefer to call intermittent. One that fits the latter group appeared last week and we can say that it is the most widely read newspaper ever received. *The Northern Moaner* is the semiofficial mouthpiece for the annual meeting of the Canadian Institute of Mining and Metallurgy. Issued at the time of the meeting in Toronto, it carried the earthshaking news story "Girl Watching Holds Second Place Among The Manly Pastimes." We have eagerly waited for a break on this news but were disappointed that this exclusive release was never sent to us. Many other news features and stories of equal status and importance were backed up with advertisments such as the one reading: "Use the new Edison Cap Lamp—it leaves both hands free to work in the dark."

C. M. Cooley



Bucyrus-Erie 1150B dragline for coal stripping at the Chieftan No. 20 mine, Riley, Ind. Maumee relies on this and similar units for overburden removal at its mines.

Report on Akremite

by Charles M. Cooley, Editor

WITH explosives representing over 10 pct of the cost of operating the entire company, the Maumee Collieries Co., Terre Haute, Ind., inaugurated a program to develop a low-cost blasting agent. Results of more than two years' work were announced on May 1 by Hugh B. Lee, president of the company. Utilizing a mixture of commercial-grade ammonium nitrate and carbon black packed in polyethylene bags, Maumee has been able to reduce blasting costs by 50 pct. The lower costs are brought about principally by elimination of high transportation charges on fixed explosives and use of low-cost material (commercial NH_4NO_3 and carbon black). The Akremite blasting method incorporates a 20-lb cap-sensitive primer to detonate the stable explosive.

Maumee now uses Akremite exclusively in its stripping operations producing more than 2 million tons of coal per year. The explosive is employed to break about 25 million cu yd of overburden that covers the coal.

One centrally located plant mixes all the explosives for the strip mines. During peak production periods company operations require that over 8000

lb of blasting agent be prepared daily in the converted truck-garage explosives plant. Ammonium nitrate is trucked in by three company-operated vehicles from the Spencer Chemical Co. plant in Kansas. Delivered price is about $90 per ton. Carbon black is supplied by the R. T. Vanderbilt Co. and the polyethylene tubing for making the bags is obtained from the Visking Corp.

The Maumee Collieries applied for patent on Akremite blasting early in 1954, and on Mar. 8, 1955 it was granted by the U. S. Patent Office. The company does not wish to go into the business of manufacturing commercial explosives. Accordingly, Maumee is exploring the possibilities of a licensing arrangement that will allow the industry to employ Akremite blasting in either of two ways: 1—the purchase of low-cost explosive for established manufacturers or 2—manufacture by licensee.

During the two years of testing, numerous variations in the technique have been employed. Over 8 million lb of Akremite have been detonated without a misfire. Blasting efficiency of this *homemade* explosive has been compared pound-for-pound with more than 20 of the explosives commonly used in open-cast mining, including three types of liquid oxygen. The long-range investigations have convinced Maumee officials that better fragmentation and lower costs are available with Akremite.

Advantages of Akremite Cited

Costs: Akremite costs less than any high-powered explosive used for bank shooting. Ammonium nitrate, the principal ingredient, is currently priced at about 3¾¢ per lb at the point of manufacture. All constituents can be transported at ordinary commercial freight rates rather than at the higher charges for fixed explosives. Labor and materials are relatively inexpensive. To date, Maumee's total costs for material, mixing, packaging, and delivery have averaged about 6¢ per lb.

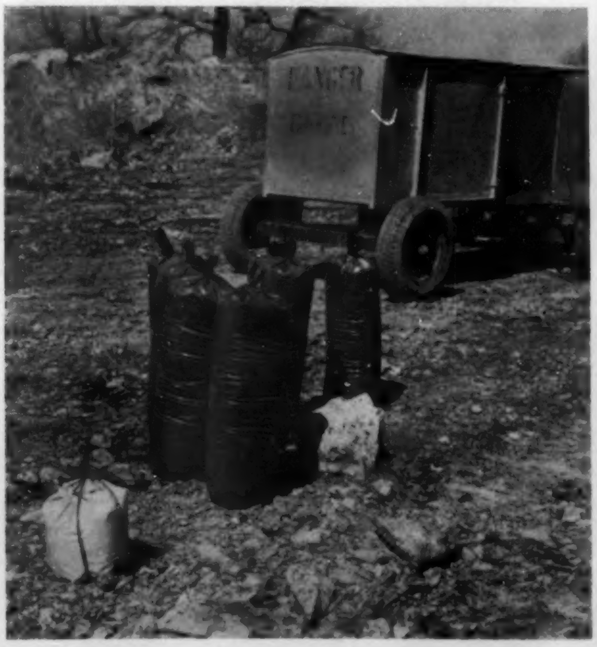
Loading Techniques: Conventional loading methods are employed with slight variations for the Akremite blasting method. Procedures in the use of detonators and detonating fuse, connections, and delays are standard practice for regular explosives. Any number of holes may be charged as drilled and fired when desired, since the packaged mixture is both stable and moisture resistant.

Fragmentation: After a year of testing, Maumee management believes that Akremite gives better breakage than commercial ammonia dynamites. This conclusion was based on the time cycle of the dragline and the yardage produced. In a period during 1953, a Bucyrus-Erie 1150B dragline was checked while digging a bank blasted with fixed explosives, and again in same period during 1954, in an area blasted with Akremite. From the swing chart records it was determined that in 1953 the machine averaged 77.1 cycles per hr of digging, while in 1954 this had increased to 81.6. In the corresponding period at another operation, a 1250B dragline increased the cycles per hr from 77.1 to 80.3.

The 1150B was digging a 62-ft bank with two seams of hard dolomitic limestone. The other location was 56 ft deep and consisted of hard shalestone and massive sandstone. Both areas are considered to be hard digging, and good fragmentation is essential for high production with draglines.

RIGHT—Head-on view of new 50R rotary drill putting down a 10⅝-in. blasthole at an Indiana operation. Just to the left of the machine blasters are loading the hole just drilled.

BELOW—Close-up of the explosive, primer, and powder wagon used by the Maumee collieries. The large black bags are Akremite explosive and the smaller package is the 20-lb primer with detonating fuse attached.



Comparison of Overburden Removal Cu Yd per Hr of Actual Digging

	No. 20 Mine 1150B Dragline		No. 27 Mine 1250B Dragline	
	1953* Explosive A	1954 Akremite	1953* Explosive A	1954 Akremite
April	1286	1489	1593	1930
May	1419	1411	1704	1687
June	1455	1531	1252	1627
July	1450	1630	1978	1946
Average	1403	1515	1632	1847

* Volume strength—65 pct

It is believed that improved fragmentation is directly related to packaging. The pliable plastic bags fill the opening tightly when dropped into the hole. The more rigid cartridges of commercial explosives do not. The voids left in the hole by the nonconforming packages tend to produce a slap at the time of detonation, causing intense fragmentation adjacent to the hole but decreasing toward the midpoint between the holes. With the polyethylene bags, there is no lost motion because the blasthole is filled. The energy produced is utilized more effectively to give relatively uniform breakage throughout.

Convenience: The mixing and packaging of Akremite is a simple process using inexpensive equipment. The plant built at Maumee during the experimental period was rudimentary, but it proved efficient. Proximity of the source of explosives to the operation effects a large saving in time and expense —storage of raw and finished material is another measure of economy.

Safety: Extended experimentation has indicated that the ingredients of Akremite, individually or mixed, are not cap-sensitive. Therefore, it stands to reason that the blasting agent is less hazardous to handle, store, and transport than most commercial explosives. Maumee Collieries has had no experience with a missed shot, but it appears that digging into unfired cartridges would not be dangerous. The company has not had a single missed hole in shooting Akremite at its operations. In addition to greater convenience, the use of the primer package developed by Maumee (20-lb cap-sensitive explosive in polyethylene bag) virtually eliminates the powder headaches typical of gelatin dynamites.

Development of New Blasting Agent

Use of ammonium nitrate, a commercial fertilizer, as a blasting agent is by no means new. Ammonia

TOP—A 48-hole blast using Akremite shown at the time of detonation. Blasting results with the homemade mixture have been excellent, according to Maumee management.

CENTER—Close-up of the same area immediately following the shot. Breakage is good, making the operation of the dragline easy and productive.

BOTTOM—Mixing room at Maumee's powder plant, showing simple equipment necessary to produce the explosive. All electrical drives and lighting are outside for safety purposes.

dynamites are made of various combinations of nitrate and nitroglycerin. Other blasting agents, with an accelerator other than nitroglycerin, are marketed under various trade names as insensitive quarry explosives.

The idea of using ammonium nitrate came to Robert Akre, drilling and blasting superintendent for Maumee. It has been common knowledge for years that although not cap-sensitive, NH_4NO_3 containing less than 1½ pct of moisture could be secondarily detonated by a fixed explosive. It was known also that a mixture of the nitrate compound and an oxidized material would produce better results because of the increase of gas volume.

Key to the success of Akremite appears to be in the selection of the oxidizing agent and packaging. Mixing an average of 5 pct carbon black with granular ammonium nitrate eliminates much of its tendency to cake. Caking in rigid cartridges renders the mixture less sensitive to detonation. The pliable plastic bags insure proper confinement and intimate contact of the units.

The general pattern used to blast the 50 to 60-ft banks in the open cast mines is basically a 27-ft hole spacing in the rows, with 30 ft between the rows. The holes of each row are offset halfway from the preceding line of holes producing a diamond pattern. In proceeding down the bench, four rows of holes are drilled. One crossrow of holes is left undrilled in each series of 12 so that drilling and blasting can be carried on continuously without fear of propagation from section to section. All holes are fired with Primacord, with a 26-millisecond delay between rows and 17-millisecond between holes in the row.

Oldest Stripping Company

Maumee Collieries Co. has registered a long line of firsts in the industry. Going back to 1911, the forerunner of the present company opened up a strip mine in Indiana which was the beginning of the oldest strip-mining organization in the U. S. The company has pioneered in use of large draglines for coal stripping. Although it owns several large shovels, the majority of the overburden removed now is handled by draglines. More recently, Maumee helped to develop the 50-R rotary blasthole drill. The first of these machines built was put in service at No. 27 mine. The 50-R drill has averaged over 100 ft per hr of 10⅝-in. hole.

Headquarters for the operations is Terre Haute, Ind., where Hugh B. Lee, president and general manager, guides his competent staff. Among the many stationed there are: D. W. Aten, vice president; Lafe Stewart, chief engineer; and Robert L. Akre, superintendent of drilling and blasting. The new blasting agent, Akremite, was largely developed by Mr. Akre and so bears his name.

TOP—Warehouse at the Maumee Collieries for storage of raw materials as well as mixed Akremite. On the left are 100-lb bags of commercial ammonium nitrate and in the foreground is the explosive ready for transfer to the nearby mining operations.

CENTER—Exterior view of the mixing room of the Colonial Coal Mining Co. The roof of the mixing room is constructed of translucent material to eliminate interior wiring for lights.

BOTTOM—A 55-gal barrel is virtually the only equipment required in Colonial's mixing room. Over 2 million lb of Akremite was produced with these facilities in the past year.

Portable underground power units are useful in operations where ac machinery is deployed in areas far from stationary load centers. Miner in photo is resetting the circuit breakers for the output.

Portable Units for Underground Alternating Current Supply

by D. E. Musgrave

THE question of alternating current vs direct current has become an important consideration to the mining industry. Rising production costs demand lower investment, which, in many instances, can be realized by the use of ac mining machines. Generally ac motors, control systems, and distribution and power conversion equipment can be installed for approximately 50 pct of the first cost of their dc equivalents. This basic saving has made ac mining a serious competitor for the traditional dc mining systems.

With the increased use of ac voltages underground, there has developed the problem of conveniently converting distribution voltages to usable 480-v power. Power at low voltages should not be carried for comparatively long distances, and the transformation should be made at the point of use. Otherwise, serious voltage regulation problems and objectionable line losses will occur.

Distribution circuits enter the mine at the portal or in a borehole and are carried throughout the mine. At the working point it is necessary to transform the distribution voltage to a lower voltage suitable for the mining equipment. This is accomplished effectively in the fresh air passage by dry-type portable load centers. In addition to furnishing electric power for mining machines, the load centers can include accessory equipment to provide all power at the working location, for lighting, low voltage rectifiers, and small hand tools.

D. E. MUSGRAVE is with the Specialty Transformer Dept., General Electric Co., Schenectady, N. Y.

The heart of a mine load center is a dry-type transformer. Since every application is different, depending upon the user's power system and type of mining machines, the accessory equipment is designed to fit the user's specifications. High voltage terminals and circuit protective devices, transformer taps, and low voltage circuit breakers and connectors are tailored to the specific application. The unitization of this equipment with the transformer provides a power package that is easily handled and connected. Recommended ratings are 45 to 500 kva with primary voltage of 2400 or 4160 v and secondary voltage of 240 or 480 v, grounded wye.

Dry-type mine load centers are designed specifically for underground use. All equipment is contained in a ventilated steel NEMA type I enclosure suitable for the conditions present in mines. It is not practical to build equipment for smaller veins, and the load centers have been standardized at 36 and 42-in. height. Width is 55 in. max for the recommended kva ratings. The length will vary from 75

to 125 in. depending upon the rating and the accessory circuit equipment. Portability is a valuable asset, and the load centers are provided with suitable skids and eyes for towing. If necessary, the units can be arranged for lowering endwise down a vertical shaft.

Installation

Similar to any type unit substation, the primary protective equipment of load centers depends upon the power system layout and the necessary interrupting capacity. Oil fuse cutouts or oil circuit breakers are suggested since they serve as load break disconnect switches in addition to protecting the distribution circuit. Air-insulated switches are generally unsatisfactory because of space limitations. The primary cable is terminated at the load center with a disconnecting plug and receptacle or is brought through a cable clamp to the switch terminals. This latter method may be preferable since the connector is eliminated and a length of cable is tied directly into the load center to serve as a cord and plug set. Some distribution systems may not require protection, and in this case the switch is omitted and the primary cable is connected to the transformer.

The transformer section consists of three single-phase, 80°C rise, dry-type units having class B insulation. As such, it is nonexplosive and fire-resistant. One phase can be removed in case of failure. By ASA standards, class B, dry-type transformers are designed for a maximum ambient temperature of 40°C and a maximum operating temperature of 120°C. Since the ambient temperature underground rarely exceeds 25°C, class B transformers will run cool, increasing life expectancy and reliability.

Wye-wye connections should be avoided and the transformers are usually connected as a delta-wye bank. If a dual primary of 2400 delta/4160 wye is necessary, the secondary can be delta connected and a zig-zag grounding transformer provided to establish the low-voltage neutral. Some operators may have both 240 and 480-v machines and need mine load centers that are reconnectable for either output voltage. In this case, the transformers are furnished with a low voltage rating of 240x480 v. It is recommended that the transformers be provided with taps below normal primary voltage to compensate for line drop as the load center is moved away from the source. Tap changing terminal boards are generally unsatisfactory for mine use because of air-borne particles which can collect between studs, causing a short circuit in the high voltage coil. For this reason, the terminal boards are omitted and provision is made for changing taps at the coils.

The output of the mine load center is protected by circuit breakers. Molded-case F to L frame breakers can be furnished in any combination of trip ratings up to a total of six breakers for controlling individual loads. Each feeder is isolated and protected by its own breaker so that a fault in one will not affect the other circuits. If the transformers have a dual rated 240x480-v secondary, the breakers are furnished with trip ratings corresponding to the preferred voltage rating. In some cases, one large load (over 600 amp) is to be operated from the mine load center, and a large air circuit breaker is provided for this application. Secondary terminals can be furnished for clamp type or coupler connection to match the type receptacle and plug now being used or preferred by the mine. If necessary, the connectors can be eliminated and cable clamping blocks, similar to those on the primary cable, furnished for feeding the cables through the case to the circuit breakers and the ground bus. Some operators prefer a receptacle and plug with built-in resistor and switch interlock arranged to activate a shunt trip coil causing the feeder breaker to trip upon extraction of the plug.

Safety Provisions

Portable machines cannot be adequately grounded, and in the event of a fault a hazardous voltage may appear between the frame of a machine and ground. This is a dangerous condition, and an operator in contact with the frame may receive a lethal voltage. A low impedance fault will draw enough current to cause the circuit breaker to open. However, if the impedance is high, the current may not be large enough to clear the fault and the high voltage between the machine frame and ground may exist indefinitely. A high degree of protection is obtained by limiting the ground current—and consequently the voltage between the frame and ground—to a value that is not considered dangerous to human life. This protection is accomplished in the mine load center by a ground fault circuit consisting of a neutral grounding resistor, for limiting the ground current to a maximum of 5 amp, and a plunger-type relay for activating the shunt trip coil of the secondary circuit breaker. A ground wire is carried to the frame of each machine. With 240x480-v dual secondary transformers, the grounding resistor must be suitable for reconnection when the transformer voltage is changed. Each circuit breaker is provided with a separate relay to open only the circuit that has a fault. When a breaker opens, the operator can immediately identify the fault. If the relay target is tripped, the fault is phase to ground; if the relay target is not tripped, the fault is phase to phase. All ground protective equipment is rated continuously so that the protective circuit will not burn open if the circuit breaker fails to clear the fault. To detect partial faults, the ground relays can be set for low pick-up (2 amp).

Single phase 240/120-v power supply is provided for mine lighting and for powering small 120-v equipment. This system consists of a separate lighting transformer, a two-pole circuit breaker, and a lighting panel board.

Numerous Applications

Because of the lower investment costs, there have been many recent developments and applications of ac power to the mining industry. One development of note is a system of belt conveyors and loaders for transporting material from the faces to a central underground railhead. The ac-powered equipment is flexible and can be changed or expanded as the workings advance. Another application involves the combination of motor starters with the load center. Reduced voltage motor starting systems are included as an integral part of the load center; and all equipment, except start and stop buttons and overload devices, is housed in the enclosure with the transformer. Motor-starting autotransformers and reactors are eliminated since the main transformers can be designed with reduced voltage starting taps. This application can be particularly advantageous where small amounts of motor power are required at scattered intervals, such as for a long conveyor. Other uses include continuous mining machines and loaders, now operated successfully with ac power furnished by mine load centers. Versatility is the prime asset of mine load centers.

The Geologist's Role:

Waste Disposal—Vital To Atomic Power Development

by John M. Warde and Raymond M. Richardson

WHAT to do with atomic wastes is one of the major problems of the atomic age. Unlike other waste materials, these cannot be burned, evaporated, or filtered, and the transfer of radioactive material from one physical or chemical state to another is not a complete answer, because only time diminishes radioactivity.

Rate of decay of radioactive materials varies from a few seconds to several thousand years and cannot be altered by known economic methods. At present the Atomic Energy Commission and its contractors are coping with the situation adequately. Intensification of private development of atomic power could, however, pose problems in the nation's nuclear energy program.

One way to dispose of radioactive waste in liquid form is to release it into the ground. The problems of this method are basically geologic. Reliable information on the prevailing geologic and hydrologic features of the disposal area is fundamental in determining the effect of such releases in a given locality and in evaluating the potential hazards to water supply. Low level liquid wastes are sometimes discharged directly to the ground from operating disposal schemes. Radioactive contamination of the subsurface is also possible from accidental surface spills, seepage from liquid waste holding facilities, failure of underground liquid waste storage tanks, and from the underground leaching of buried solid wastes. Fall-outs from atomic weapon tests may also find their way into the ground as a result of percolation.

In addition to the job of controlled release of radioactive wastes, there is the problem of protecting the environs of atomic-energy sites in event of accidental discharge of radioactive materials.

Radioactive wastes arise from several sources, including chemical separation processes in reactor operations, reactor coolants, laboratory research on radioactive materials, concentration processes for liquid and gaseous wastes, metallurgy and the machining of fissionable materials, and uranium ore processing.

Current methods for handling radioactive wastes are summarized in Table I. The principal problem in the safe handling and disposal of such wastes occurs in the chemical processing phase of nuclear reactor operations where unused uranium and plutonium are separated from fission products. Fluids used may be highly radioactive. Sufficient heat may be generated in the liquids by radioactive decay processes to cause boiling or evaporation. Characteristics of liquid process wastes are dependent upon the reactor system that produces them. Generally, they are uniform for a given system. In the case of a reactor where fissionable material is in the form of a soluble salt dissolved in water, waste would be comparatively free of solids and precipitants. On the other hand, process wastes from the acid dissolution of solid, aluminum canned uranium fuel elements will contain large quantities of dissolved aluminum nitrate and nitric acid.

Dissolved solids in reactor cooling water become radioactive and the liquid must be kept in storage to allow decay to safe levels before discharge. Liquid wastes produced in a laboratory are unpredictable both in composition and activity level. Laboratory waste liquids are monitored and if activity is high, stored in tanks. If low, they are discharged to the process-waste system and eventually flow into the ground or surface watercourses. Liquid wastes with dangerous levels of activity are placed in semipermanent storage.

Water used for cooling the reactors at the Hanford Atomic Products Operation, Richland, Wash., is discharged into the Columbia River after a period of storage. Low activity wastes are permitted to seep into the ground through *cribs*. The cribs consist of revetted pits. Radioactive elements adhere to soil particles as the waste infiltrates into the terrain. At Oak Ridge National Laboratory highly radioactive wastes are concentrated and stored in underground tanks. Low level wastes are first discharged into a settling basin, pass into White Oak Creek, to White Oak Lake, and finally into the Clinch River. Oak Ridge is experimenting with storing moderately radioactive wastes in large unlined waste pits or *lagoons*. This method, like that practiced at Hanford, depends on the ability of soil to remove activity as the liquid seeps through the zone of weathered rock and finds its way along bedrock to the White Oak Lake drainage system.

Oak Ridge handles its solid wastes by placing them in a trench and then covering with concrete, original soil, or both, depending on the kind of contamination. Brookhaven accomplishes this by pack-

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ing wastes with concrete in sealed drums and dumping them at sea.

Gaseous and airborne wastes are normally diluted to safe levels upon release to the atmosphere. Careful meteorological checks are taken of prevailing conditions before releases are made. At Oak Ridge periodic readings taken of the air within a mile radius of exhaust stacks show activity to be about twice the average cosmic ray background—a safe condition and one representative of normal readings at other sites.

Geologic and Hydrologic Considerations

The ideal ground area for radioactive liquid waste release is one where the geologic conditions prevent migration of the materials or slow migration enough to allow radioactivity to decay to a safe level. Each site presents a distinct problem dependent on geologic and hydrologic characteristics. Before suitability of a site can be determined one must know the factors controlling the rate and direction of liquid flow into the subsurface. Practically all rocks are collections of discrete particles more or less perfectly cemented, rather than solid masses. Thus, it follows that nearly all rocks are pervious to fluids to some degree. Permeability of natural earth material varies greatly. Laboratory determinations show that gravel permeability may be 450,000 times that of a clayey silt. Much wider contrasts exist. Fluid contained in porous soils and rocks is not static, but is in slow, definite motion called laminar flow. Movement of fluid through a porous medium is caused by the difference of pressure head from point to point, in the case of ground water nearly always caused by gravity. Rate of movement depends chiefly upon the permeability of the rock, the hydraulic gradient, and temperature of the fluid. High temperature fluids usually flow at a rate greater than that of cooler fluids. Under normal conditions ground water flows at rates varying from a few feet per day to a few feet per year, although flows of several hundred feet per day may occur in cavernous limestones.

In unconfined or water-table aquifers, fluids released above the water table infiltrate the soil and rocks below the surface, move down through the unsaturated region and enter the saturation zone. In the unsaturated region movement is generally downward. Some fluid may return to the surface by evaporation or transpiration. Slope or configuration of the water table usually conforms to the land surface. Fluid movement tends towards neighboring streams and lakes. While fluids introduced into unconfined aquifers may return to the surface near where they were introduced, in regions where rocks of the unsaturated zone are comparatively dense or subsurface frozen, fluid percolation is retarded. Other regions may consist of more permeable material and downward movement is more rapid. Im-

Contaminated solids at Oak Ridge are placed in graves excavated to bedrock and covered with earth or concrete, depending on the contaminants.

Table I—Handling of Radioactive Wastes in Atomic Energy Operations

Type	General nature	Usual treatment
Liquid	Metal waste containing fissionable metals; radiochemical waste containing high concentrations of radioisotopes; reactor cooling water; process water composed of water which is actually or potentially contaminated.	*Shorter half life wastes*—Monitor, store to permit radioactive decay to safe levels, dilute and release directly to surface water or to the ground or dispose of by incorporating in concrete and burial at sea. *Longer half life wastes*—Concentrate by evaporation, filtration, precipitation, crystallization, or ion exchange and place in semipermanent storage in underground tanks.
Gaseous or airborne	Radioactive rare gases, chemically reactive gases, and radioactive solid particles.	Filtration by mechanical separators and electrostatic precipitators. Where necessary filtration is preceded by scrubbing. Filtered gases released to atmosphere through tall stacks under meteorological control.
Solid	Contaminated clothing, process equipment, building materials, laboratory apparatus and glassware, biological specimens, air filters and solidified liquid wastes.	Except for some closed cycle incineration of combustible wastes, bulk of solids are disposed of by burial in the ground or by incorporation in concrete and burial at sea.

View of *tank farm* at Oak Ridge shows surface plumbing system associated with the underground tanks used to hold radioactive liquid wastes.

pervious strata above the main water table could support perched saturated zones.

Ground water is confined under hydrostatic pressure where artesian conditions exist. Water bearing strata are covered by less pervious rock penetrated only with difficulty by downward percolating fluids. Recharge to such aquifers occurs chiefly in or near their updip outcrops, from which the fluids move to discharge points. Direction and character of flow in confined aquifers is relatively independent of detailed surface topography, although ordinarily movement is from the higher to lower topographic levels underlain by the aquifer.

One element to be considered in the underground migration of radioactive wastes is the disruptive effect on the normal hydraulic gradient caused by withdrawal of water from wells. When a well is pumped water levels are drawn down in the vicinity and a cone of depression is formed. Movement from all directions toward the well is induced by the hydraulic gradient. As pumping continues the cone expands and movement is induced from increasingly distant points. Rate of withdrawal, hydrologic properties, aquifer dimension, location of areas of recharge and discharge determine the size, shape, and rate of growth of the cone.

Difference in density between liquid waste and ground water or other natural fluids influences the rate and direction of waste movement. Fluids with greater density than the natural fluids in the formation will move downward through the ground water as a mass. Wastes lighter than the natural fluids will be buoyed up by them.

An important role is played by dilution in safe disposal of liquid wastes into surface watercourses, but apparently is a less important factor where ground water is concerned. Knowledge of the mechanics of flow of fluid wastes through permeable material saturated with ground water is at present imperfect. However, under conditions of laminar flow contaminants move essentially as one stream with relatively little dilution.

Sorption Properties of Clays

Various clays and other minerals have been found under certain conditions of pH and temperature to have a great affinity for radioactive contaminants. How the isotopes are removed from liquid waste is not clear. Table II shows the results from laboratory jar tests on the removal of radioactive materials by various clays and vermiculite, as reported by T. W. Brockett and O. R. Placak. They point out that base exchange ratings do not indicate the efficiency of clays or soil for removing radioactive materials from solution. They also conclude that although certain removals are obtained with one chemical form of a radioisotope, it does not follow that the same results will be gotten with other chemical forms of the isotope.

Table II—Removal of Radioactive Materials by Various Clays
(Brockett and Placak)**
(Jar Stirring Method with 1 Gram of Clay)

Sample Number	Type of Clay Locality	Percent Removals After 2 Hours' Contact						
		Ce^{144} $3.9x10^{-3}$ $\mu c/ml$	P^{32} $3.5x10^{-3}$ $\mu c/ml$	Ru^{106} $4.8x10^{-6}$ $\mu c/ml$	Sr^{89} $1.1x10^{-7}$ $\mu c/ml$	Sr^{90} $4.1x10^{-3}$ $\mu c/ml$	Zr^{95} $0.78x10^{-3}$ $\mu c/ml$	MF P* $4.1x10^{-2}$ $\mu c/ml$
1.	Kaolinite—Mesa, Alta, N.M.	92.50	51.58	69.39	30.40	46.25	98.08	70.87
2.	Halloysite—Eureka, Utah	91.82	72.90	77.95	26.15	61.63	98.32	89.77
3.	Montmorillonite—Little Rock, Ark.	69.21	88.27	64.40	63.03	74.50	97.18	94.70
4.	Montmorillonite—Cameron, Ariz.	89.00	31.89	52.89	57.44	71.35	91.05	92.44
5.	Nontronite—Manito, Wash.	85.16	44.50	60.77	29.26	71.49	92.25	94.75
6.	Metabentonite—Tazewell, Va.	76.05	68.28	53.61	16.10	53.46	83.59	86.20
7.	Metabentonite—High Bridge, Ky.	88.20	80.05	68.08	41.75	59.87	97.13	86.16
8.	Conasauga Shale—Oak Ridge, Tenn.	90.91	72.67	71.69	14.15	55.69	96.63	86.88
9.	Vermiculite (nonexpanded) —Sylva, N.C.	95.94	60.15	68.69	26.77	65.53	93.87	—

* Mixed fission products ~16% Ce^{144}, ~20% trivalent rare earths, ~2% Ru^{106}, ~20% Sr^{90}, 21% Cs, ~21% unknown.
** Brockett, T. W. and Placak, O. R.: "Removal of Radioisotopes from Waste Solutions by Soils—Soils Studies with Conasauga Shale." Eighth Industrial Waste Conference, Purdue University, 1953.

How much radioactivity from a migrating waste solution is fixed in the enclosing rocks and the permanence of the fixation when the rock is alternately wetted and dried by filtration or by fluctuation of the water table is important in control of underground activity movement. Sorption properties of clays are significant where fluid wastes are released to surface waters, since the turbidity in a water body may alter distribution of the activity and the sediment on settling may increase activity on the bottom.

Chemical Interactions

The possibility of chemical interaction between liquid waste and ground water, other natural fluids, or the enclosing rock is a major factor in evaluation of migration activity. Permeability reduction and eventual plugging of rock pores can be caused by presence of suspended solids, colloid swelling, aggregate slaking, bacterial growth, or precipitants. Liquids containing calcium salts could precipitate calcium carbonate and calcium sulphate when coming in contact with dissolved carbonates and sulphates. Acid wastes traversing carbonate rocks may develop or enlarge solution channels in such rocks.

Liquid wastes arising from processing aluminum canned uranium slugs, assuming it contains aluminum nitrate and nitric acid, coming in contact with calcareous rocks would form a gel which could seal surrounding rock. Nitrate in high concentrations constitutes a potential health danger. Many public health authorities hold the opinion that drinking water containing more than 10 to 20 parts per million of nitrate nitrogen may be responsible for methemoglobinemia. Infants with this disease are called blue babies.

Decaying radioactive liquids may generate considerable heat. Heat removal rate by surrounding rock is dependent on the thermal conductivity of the rock and its contained water.

Site Investigations

In seeking a site for radioactive liquid disposal all sources of information should be integrated—geologic, lithologic, stratigraphic, and structural features, private, state, and federal topographic, geologic, and hydrologic maps and reports—in particular, information on ground water occurrence.

The thin walled aluminum probe of this radioactivity logging unit contains a Geiger tube and preamplifier. This is lowered into well by cable reel at constant speed. Activity is recorded on strip chart.

This unlined disposal pit is used for liquid wastes at Oak Ridge. The pipes extend into the sand cover to charge wastes and provide observation and sampling points.

Test drilling should be carried out to determine ground water conditions and define the lithologic and structural features of the subsurface. Exploratory drilling should reveal perched water, confining beds, and other flow barriers, faults, fissures, and other openings permitting the flow of liquid contaminants. Electric logging is a useful adjunct to drill cores or cuttings. The program would provide samples for petrographic examinations, isotope-retention studies, radioactivity determinations, chemical interaction tests, and measurements of hydrologic properties. Holes can serve as observation wells for water-level measurements and monitoring of radioactivity by radio logging. Under the heading of hydrologic investigations come permeability tests, water-surface mapping, and determination of the rate and direction of ground water movement. Liquid wastes released to surface water should be hydrologically studied for the rate of dilution under various conditions. Velocity measurements in the case of flowing streams and sampling to determine dispersal pattern of the activity in the water body are necessary in the latter case.

Research and Development

Geologic aspects of the disposal of radioactive wastes are part of the program supported by the AEC. Detailed geologic and hydrologic studies are underway in cooperation with the U. S. Geological Survey at all installations where radioactive-material handling is a problem. More work is needed. Many branches of science are already involved in research on the mechanisms of retention of radioactivity by certain minerals and development of methods for permanent fixation of radioactivity in the ground. Reports from Brookhaven on the fixation of radioactive materials on clay by sorption processes and subsequent heat treatment to make the action irreversible have been encouraging. Also under consideration is the possible disposal of radioactive wastes in abandoned mines, deep wells, and salt domes.

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Canada's New Uranium Camp at Blind River

Large tonnages offer promise of large-scale operation

by Howard Steven Strouth

THE Blind River mining camp in Canada is all set to stage a major revolution. Enthusiasts on the scene say it will bring large-scale mining to North American uranium operation. If orebodies already discovered live up to their promise, it will be anything but the usual business of a few men handpicking orebearing rock out of small mines. Because of the geological structure of the region referred to generally as the Algoma district the ore may prove an extremely lucrative enterprise for years to come. The present center of activity is in Ontario about 75 miles east of Sault Ste. Marie, and just north of Lake Huron.

It stacks up as one of the large uranium discoveries in the Western Hemisphere. For a change modern mining machinery working against large ore faces of predictable grade will enable mine operators to send a product to mills of several thousand tons daily capacity. Ore shapes-up as worth more than \$20 per ton. Already, many millions of tons of ore have been outlined and apparently reserves are sufficient to keep the proposed large mills going for decades. And the end is not yet in sight.

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This region in the Sudbury subdivision has been known for decades as having occasionally rich but sporadic occurrences of nickel, gold, pyrite, and other minerals. Because of the unpredictable mineralization for more than 80 miles along the contact line of a huge reversed "S" there was no record of successfully organized mining in the district—until the present one.

On many of the properties going full blast toward production, trenches remaining from old workings are still in evidence. In 1846, according to the record, the once important Bruce Copper mine was still in operation. One uranium mineral was identified in 1847 by the American geologist J. L. Le Conte, who called it corasite. More than 100 years later, Le Conte's discovery led to the discovery of the Camray field, 70 miles north of Sault Ste. Marie. However, the find revealed only narrow, short pitchblende-filled fractures of no commercial value. One year later, radioactive conglomerates were discovered in the Algoma district.

The 1949 determinations were neglected because of a fallacious theory that radioactivity resulted ex-

LEFT: Pioneer Jeep crosses primitive bridge in Blind River area. RIGHT: Cookhouse at Stanleigh property, complete with propane bottles for stove.

LEFT: Morissette's camp, Milliken Lake Uranium Mines Ltd. CENTER: Summertime scenery in Township 155. Elliot Lake just shows in distance. RIGHT: Seaplane proves its value in reaching places such as Gullbeak Lake.

LEFT: Radioactive conglomerate showing, Hutton township. CENTER: Summer camping at Gullbeak Lake. RIGHT: Thirty-ft tripod and canvas drill shack is one of more than 50 drill set-ups working in the area at present.

clusively from occasional thorium crystals. One man, Frank R. Joubin, chemical engineer turned geologist and prospector, recognized the importance of the Algoma find.

But the disclosure of the tremendous economic value of certain South African conglomerates brought a reappraisal of Algoma. With the help of the Hirshhorn group, Mr. Joubin staked some 1500 claims which resulted in the Pronto, Peach, Quirke Lake, Elliot Lake, and Nordic Lake deposits—a major quantity of uranium ore.

The upper portion of the reversed "S" formation represents a shallow cup. Formations carrying radioactive ores generally dip at 10° to 16° and eventually become horizontal, except for some occasional faulting, at a depth between 2500 to 3000 ft. It is indicated that the uranium carrying ore layers continue throughout this upper reversed "S" formation, connecting the Elliot Lake and Quirke Lake region through parallel, tabular orebodies thousands of feet long containing uranium minerals. Diamond drillholes are still scattered but evidence is fairly clear on this point.

A theory developed meanwhile makes it appear that on level one, the Quirke Lake, and Nordic Lake ore horizons might overlap, actually doubling the expected width of formation. Holes now going down should settle both the continuity of ore through the area, and validate or kill this particular theory.

Right now, developments in this particular region outdistance any blocked out uranium reserve in the world. Among those taking part in the development of the Blind River camp are: Preston East Dome, Algom Uranium, Buckles Algoma Uranium, Pronto Uranium, Stanleigh Uranium, New Jersey Zinc, Consolidated Dennison, Vitro Chemical, and some of the large British interests, such as Rio Tinto. A few of the operators have given an inkling of future plans. Algom Uranium plans two uranium mills handling 2500 to 3000 tpd each. Algom Uranium shares at present market price represent a public investment of more than $90 million plus a $51 million 5 pct bond issue. Pronto Uranium plans to have a 1000-ton unit completed by September 1955. Current statements indicate that Pronto has a bond issue of some $6 million and 2½ million shares of $1 stock outstanding, representing a public investment of more than $12 million at market price.

Stanleigh is intent upon developing the Elliot-Nordic Lake areas, although the parent company, Standard Ore & Alloys Corp., purchased an interest in the Boise Yellowknife holdings near Quirke Lake. The northernmost part of the Algoma district has developed considerably during the last few months, with drillholes on the Consolidated Dennison property intercepting more than 15 ft of 0.12 pct uranium oxide at 1800 ft.

Geology

Uranium occurs in the Bruce Series in the so-called Mississagi quartzite overlying the pre-Huronian granites. The basal part of this formation carries the mineable uranium beds. The upper portion of the formation shows uranium bearing floats,

which although not of commercial value, always indicate such beds at a lower depth if the contact zone has been established. Several such floats have been found by drilling through the basal formation on the Stanleigh, Pronto, Peach, and the two Algom properties. Drilling has substantiated the theory. Because of that, aerial surveys were flown by Algom Uranium which established these surface showings. At first the major effort was directed toward discovering joint surface manifestations of the basal contact and the Mississagi formations. But subsequent drilling showed that the uranium values at such points were leached out to a depth of 70 ft. Only at several hundred foot depth down did there appear to be a mineable width of ore—of high enough grade and sufficient quantity to warrant large scale mining.

Early Results

In drilling series of holes close to the contact line, the drillhole group at the east end of Elliot Lake and north of Nordic Lake disclosed two conglomerate horizons separated by 16-ft barren zone. During April and May 1954 alone some two to three million tons of ore were proved on Algom properties over a 4000 ft length, with an average mining width of 9.8 ft. Average ore values were slightly more than 2 lb of U_3O_8 contained. The orebodies were encountered at 600 ft. Additional drilling took place parallel and farther north of these holes with 15 ft of ore showing 2.6 lbs U_3O_8 at 2300 to 2400 ft.

Additional holes by Lake Nordic eventually extended to ore zones at 1000 to 1800 ft and displayed the consistency of the ore. Uranium values and mining widths were increased. The final hole showed a total of 53 ft of uranium bearing beds with one formation almost 12 ft wide. Some layers were separated by only 2 ft of barren rock.

Based on these results Mr. Joubin estimated 30 to 50 million tons of ore in the region, and then proceeded with the negotiations for building several mills to treat between 2000 to 7000 tpd.

Theoretically, drillholes only a few hundred feet from the last site drilled by Algoma and now down 2200 ft should, on the basis of previous results, intercept conglomerate beds with uranium bearing values stronger than any previously encountered, at depths of 2400 to 2700 ft. In theory, at this particular point the gentle dip of the widening ore formations would come to a slight angle, and then continue towards the middle belt in a horizontal position, causing a thickening of the point in question.

The geology of the region has been well covered by earlier authors. Some of the major considerations stated by some of these authors concerning the north and middle belts containing the Elliot and Quirke Lake deposits are that the conglomerate may be divided into the boulder type, the quartz pebble type, and the intraformational conglomerate within the sediments. The quartz pebble conglomerate is the only one of economic interest, being the only formation in which uranium bearing minerals are found. The previously mentioned radioactive surface showings which served as indicators do not form a part of this particular conglomerate. The middle belt dips quite gently some 16° N, while the north belt dips more steeply 25° to 30° S.

Mineralogy

Radioactive mineralization consists chiefly of uranium and some thorium minerals imbedded in pyritic basal quartz pebble conglomerates. Occa-

Blind River Uranium Boom—Some of the Men Behind It.

Joseph H. Hirshhorn—A Brooklynite and financier of the rock-em and sock-em school who opened Canada's first publically financed uranium operation, Rix-Athabasca. His Algom mine at Blind River is a $50 million plus project. Hirshhorn is planning two 3000 tpd mills at Algom. He seems to be reaching for the "Mr. Big" title held by LaBine.

Constantine Grand Duke of Leuchtenberg-Beauharnais—Mining engineer, geologist and White Russian, who spent many years in Southwest Africa. A colorful figure, he holds a degree from Freiberg University and is Canadian resident engineer for Standard Ore & Alloys Corp.

Professor S. Duncan Heron, Jr.—A vice chairman of the Dept. of Geology at Duke University who worked out some of the geological features and theories for the Canadian properties.

Frank R. Joubin—A chemical engineer who switched to geology and prospecting and whose faith in Algom persuaded Hirshhorn to actively develop the property. Joubin is also the man who developed Rix Athabasca for Hirshhorn.

Colonel John H. White, Jr.—Former president of Climax Uranium. He is a member of one of the groups active at Blind River.

D. G. MacKay—General manager of Aeromagnetic Surveys Ltd., which has been flying some of the radioactive showings in the Blind River area. He worked for the Hirshhorn interests, Stanleigh, and others.

C. J. Cunningham-Dunlop—Consulting engineer and head of Pioneer Consultants Ltd. He is responsible for some of the earliest work at Blind River, particularly on the Pronto and Algom properties.

J. M. Cunningham-Dunlop—Vice president of Ventures Ltd. and a vice president and director of Stanleigh, he has been a valuable contributor of engineering and geological advice.

W. N. Millar—Author of an early geologic study and report on Blind River. He is one of the original discoverers and major stockholders of Rix-Athabaska.

W. H. Bouck, Toronto lawyer and president of Preston East Dome gold mine in the Porcupine district participation with Hirshhorn in the initial staking.—**Robert C. Hart**, Preston chief geologist who organized the staking plans—**Don Smith**, **Harry R. Buckles, Roy Poutney, Manfred Johnson,** and the late **Walter Ecclestone** were among the others who participated in the initial capture of a large block of the more promising areas.

Pro and Con

Rapid growth of the uranium boom at Blind River has been viewed with a jaundiced eye in many U. S. mining circles. Even in Canada there has been considerable concern over the tremendous speculation associated with early reports of extensive finds in this new Ontario uranium area. At least part of this attitude stems from the background of some of the men who made the early finds. Press reports in the U. S. have been scanty, perhaps from caution.

But regardless of the speculation, it is difficult to ignore a development where stock issues have far passed the $100 million mark, and where one company recently placed a $41 million bond issue with an established British mining firm.

Before security restrictions were clamped down, it had been revealed that at least 20 million tons of ore carrying about 2 lb of U_3O_8 had been indicated by initial scattered drillholes. And, the Canadian Government has contracted for over $250 million worth of concentrates.

Talks with men long experienced on the Canadian scene bring out the points troubling the more pessimistic viewers of Blind River. These observers suggest that tonnage estimates from scattered drillholes are based on an incompletely proven theory—that mining will be at considerable depth, with relatively high costs—that the ore treatment is still unproven—that mineralogical differences between the ore there and in other major camps leaves room for unexpected beneficiation difficulties—and lastly that purchase contracts do not extend beyond 1962, leaving the more distant future in doubt.

According to newspaper reports quoted in *The Northern Miner*, Ottawa has expressed worry that there may be danger of uranium overproduction in the next few years. Just how much metal will actually be needed to nuclear power applications is still in the dark, and varying statements from the U. S. Atomic Energy Commission have not helped clarify this point. To sum up: Cautious figures are saying "let us make haste slowly, with less fanfare, and less food for uninformed public stock speculation."

sionally some uranium bearing minerals are found with calcopyrite, filling fractures in the diabase sills or dykes. In some instances the larger conglomerate beds show only uranothoride and hematite. Most common minerals encountered are brannerite, pitchblende, urananite, and thucolite. Brannerite, the uranium titanate mineral containing about 40 pct U_3O_8, is the most plentiful. Brannerite has been found in just two other places in the world—as detrital crystals and grains in Idaho gold monazite placers, and in the Vosges district in France where it is found together with urananite.

Economics

It has been estimated that ore found thus far in the region could be economic even if it should go as low as 0.07 pct U_3O_8 because of the tonnages available. The reported average so far is over 2.2 lb of U_3O_8 contained.

The problems of mining at considerable depth require a substantial investment for shaft sinking and other preparatory work but unusual or difficult though somewhat more expensive.

The author's firm, Standard Ore & Alloys and its associates, sponsors of Stanleigh, feels that the nature of the deposits in the district will offer an opportunity to apply modern equipment and methods to the mining of the uranium bearing conglomerate seams. Special mechanical procedure could considerably reduce the present cost estimates.

Finally, a monumental amount of work has been done by F. A. Forward, head of the Dept. of Metallurgy, University of British Columbia, and others, on the adaptation of new extractive metallurgical processes to uranium production. The patents are held by a Crown company and information is classified. It can be revealed that successful attempts have been made to adapt the Sherritt Gordon-Chemico process for converting low grade concentrates directly to uranium oxides by a pressure leach process, to the ores found in the Blind River region. (See JOURNAL OF METALS, February 1955)

Another process on which a great deal of work has been done is a dry extraction process on the Airvent-Supersonic separation principle. This process, if successful, would at low cost effect concentration on a 1:4 ratio and reduce mill sizes and operating costs considerably.

Uranium mineralization at Blind River has principally pitchblende and brannerite occurring in microscopic crystals virtually without other metallic elements, thus avoiding difficulties encountered with carnotite and other secondary chemically combined ores. They could conceivably yield metallic uranium at a processing cost not exceeding the present leaching methods which result in only a high grade concentrate of the uranium oxides. Despite the hush-hush nature of the process, it is known that uranium oxide concentrates are valued at between $12 to $15 per lb of U_3O_8 contained, while uranium metal said to have been sold by the Atomic Energy Commission at cost, had a price tag of $50 per lb.

The final product, according to articles by Mr. Forward and Mr. Halpen, would be a uranium oxide precipitate from sodium caronate solutions. The process could also be used as an acid process in the presence of siliceous ores. Such ores containing only small amounts of sulphides are mixed with water and agitated with compressed air at 150°C. with excellent recoveries at low cost. This process has been tested successfully on Blind River ores.

The Future

Jesse Johnson of the AEC envisions the industrial and other demands of the forseeable future might absorb as much as 70 million lb of U_3O_8 per year. In the Algoma district this would be equivalent to 32 million tons of average grade ore. Thus, the demand for Algoma district ores—and indeed any other uranium ores found in the world should hold up for a long time to come.

INTERNATIONAL MINERAL TRADE SERIES

Introduction

Pattern of International Trade In Metal Raw Materials

by John D. Ridge

ONE of the most profound economic forces operating on a global scale is the movement of metals, ores, and concentrates from one country to another. A single shipment can pass through a series of ports and leave a flow map looking like some psychological nightmare. Statistical tracing often proves as difficult. How much did one given country send to another? Does the word ton represent the same thing to all people? What part did free ports and transshipment play? Where did the metal finally stop traveling and enter fabrication?

The amount of mineral produced in the form of concentrate and as refined metal can be tracked down in the *Minerals Yearbook* of the U. S. Bureau of Mines. Quantities imported by the U. S. can also be found in that publication. But the *Yearbook* will not tell what happened to the metals that did not find its way to the U. S. Even after a study of supplementary literature, such as the USBM *Mineral Trade Notes* and the publications of the International Tin Study Group and of other private and public organizations, the picture remains vague at best.

Problems are presented by synthesis of transshipment, difference in terms when referring to metal content of concentrate as against pure metal, time lag, the amount actually imported by a nation. The difficulties are monumental.

Yet, despite the many impediments, a fairly cohesive picture can be reconstructed of the pattern of international trade in major metal raw materials.

A 1936 study published by the U. S. Bureau of Mines and based on 1932 data, at least provide a jumping-off point, and a means of comparison for overall pattern change over a 20-year period. But, the earlier report omits much that is important. In the 1936 report countries are usually lumped by continent. Thus, for Europe there is no pattern established for trade between Continental nations. And because of the continental arrangement, it is also impossible to trace European export and import relationships with nations outside of Europe.

The 1952 study lacks information of trade within the Soviet bloc and with other countries.

It becomes almost impossible to convert all tonnage interpretation to a common base. But the patterns of trade are not greatly affected since other uncertainties are large.

Geography is only partly responsible for the flow of metals, ores, and concentrates. Geologic, political, and economic conditions, past and present help formulate the patterns. The extent of concentration or refining of ore in the country in which it has been mined determines its eventual destination. In most cases low grade ores are processed at least in part in the country of origin. Often enough a company operating in a foreign country will decide that it can profitably take on additional processing steps, depending upon the location of the plant. In any event, ore with a lesser degree of unwanted impurities is likely to be smelted in an industrially advanced area.

U. S. Production 1952 — 97,918,004 Tons

		Importer	
Exporter	Total	Belg-Lux	U. K.
Sweden	15,879,924	2,197,799x	4,876,000
France	9,383,851*	8,395,260xx	446,047
U. S.	5,121,242	—	—
Canada	3,434,820	—	629,468
Algeria	3,098,833	275,318	1,734,655
Chile	1,861,575	—	—
Venezuela	1,845,776	—	—
Spain	1,762,000	—	595,000
Brazil	1,560,000	66,809	91,522
Sierra Leone	1,378,959	—	1,052,852
Philippines	1,221,566	—	—
Malaya	1,007,486	—	71,731
Tunisia	992,530	—	574,017
India	695,583	—	—
Sp. Morocco	681,520	—	256,900
Norway	679,388**	24,597	61,879
Fr. Morocco	640,380	—	260,000†
Liberia	572,485	—	—
Goa (Port. India)	463,596	—	—
Belg-Luxemburg‡	448,381	—	—
Austria	276,799	60,000	—
	53,067,705	11,019,763	10,654,071
Africa	800,000		
Malaya	700,000		
China	600,000		
Russia	400,000		
Canada	300,000		
Chile	200,000		
Cuba	100,000		
Europe	100,000		
	3,200,000		

* Exports to the Saar are not included in this total. French ore moving into the Saar in 1952 was probably about 1,450,000 tons.

** About 150,000 tons to Poland.

x 500,078 tons of this to Luxemburg.

xx 3,734,916 tons of this to Luxemburg.

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Copper is almost certain to be put through at least the preliminary stages of processing in the country of origin. Lead, on the other hand, because the higher percentage of lead in the average concentrate may not be smelted prior to shipment. However, there are exceptions. Mexico mines and smelts most of its lead. The process is simple and can be carried out by cheap semiskilled labor, resulting in a finished metal less expensive than can be produced in a highly industrialized nation.

Another exception is the shipment of Bolivian tin concentrates to the U. S. The concentrate contains much undesirable material, but because the smelting process is so complicated it is beyond the capacity of Bolivian capital and labor.

Strangely enough, zinc concentrate, rarely containing as much as 60 pct metal, represents about 60 pct of the metal involved in international zinc trade, compared to only 27 pct for lead concentrate. Zinc smelting is much more involved than lead processing. Peru mined 98,000 tons of lead in 1952, smelting 48,000 tons domestically, but smelted only 5000 tons of the 122,000 tons of zinc it mined during the same year. Belgium mines practically no lead or zinc, smelted 190,000 tons of zinc and only 75,000 tons of lead in 1952.

Usually, the newer a mining industry is in a country, the less likely nonferrous concentrates will be smelted. Yet, French Morocco, after exporting all its lead concentrates in 1950, was able to smelt 40 pct of the concentrate it produced in 1952. Peru, conversely, has stepped up lead mining in recent years without an accompanying increase in smelting.

There are no set mineral economic generalities that can be applied to explain processing plants or the complexities of international trade in raw material and finished metal.

What is the significance of political control of one country by another? The continuing strength of the import export relationship between Great Britain and the Commonwealth nations indicates that trade established by political control does not dissipate when the control ceases to exist. Economic necessity often overides political and social bitterness. The Bolivian Government's expropriation of tin properties belonging to international interests has not prevented concentrates from going to British smelters in substantially the same quantities as before.

Even when the producing country switches in good part from shipping concentrate to exporting finished metal, the relationship often continues. French Morocco still sends the bulk of its lead production to France.

A nation's past economic history has a bearing on its position in the metal raw material trade. The earlier and more rapid the industrialization, the more complete will be the processing of metallic raw materials within its own borders. And the older and more advanced the industrial civilization of a country, the greater will be its dependence on mineral imports. The acceleration of this need to import is based on the extent of its mineral wealth at the start of industrialization. Also, the later a nation begins to develop its industrial plant, the larger will be the number of countries from which it imports and the smaller the amount it will obtain from each. Nations that go about the business of developing an industrial society later than their neighbors also must more intensely develop resources—although metal resources may be economically less attractive than those of other nations.

Table I—World Trade in Iron Ore, Tons

1952

Importer								
U. S.	Germany	Japan	Canada	Netherlands	Italy	Austria	Misc.	Europe
2,111,100	5,558,761	—	—	292,332	—	73,621	768,331	(13,000,493)
—	379,324	—	—	129,483	—	31,737	—	(9,383,851)
—	—	1,300,977	3,666,729	—	—	90,670	62,866	(90,670)
1,795,113	301,033	709,206	—	—	—	—	—	(930,501)
—	289,564	—	—	218,692	329,510	14,625	236,469	(2,862,364)
1,861,575	—	—	—	—	—	—	—	—
1,845,776	—	—	—	—	—	—	—	—
—	670,681	—	—	199,725	115,000†	50,235	131,359	(1,630,641)
1,010,919	120,569	—	142,665	53,364	—	29,598	44,554	(504,527)
—	300,182	—	—	25,925	—	—	—	(1,378,959)
—	—	1,221,566	—	—	—	—	—	—
—	60,215	849,811	—	25,654	—	—	2,077	(157,600)
—	—	—	—	76,416	178,915	—	163,191	(829,348)
—	—	669,052	—	—	—	10,408	16,123	(10,408)
—	278,579	—	—	116,695	20,300	—	9,046	(672,474)
—	406,601	—	—	17,782	—	12,024	156,505	(522,883)
—	292,910	—	—	20,714††	—	—	87,470	(552,910)
572,465	—	—	—	—	—	—	—	—
—	99,007	364,589	—	—	—	—	—	(99,007)
—	434,759	—	—	—	—	—	13,622	(434,759)
—	216,799	—	—	—	—	—	—	(276,799)
9,760,625	9,641,555	5,125,200	3,810,409	1,181,630	715,000	611,865‡‡	1,691,613	(33,338,194)
				1932				
—		—						800,000
—		700,000						—
—		600,000						—
200,000		—						200,000
—		—						300,000
200,000		—						—
100,000		—						—
100,000		—						—
600,000		1,300,000						1,300,000

‡ Luxemburg exported 3,002,660 tons in 1952 of which 2,606,627 went to Belgium and 379,060 to Germany.
‡‡ 326,641 tons from minor European exporters.
† Estimated.
†† Fr. Morocco reports 106,656 tons exported to Netherlands in 1st half of 1952, much of which may be included in German total.

INTERNATIONAL MINERAL TRADE SERIES
Part I

World Trade in Iron Ore

by John D. Ridge and Betty S. Moriwaki

THE pattern of current international iron ore trade emphasizes the growing necessity for the world's major steel producers to import ore. Only the U. S. could approximate its current level of production without foreign ore—for a time. Each year without foreign ore would make anything like the existing pace more difficult if not impossible. But in 1952, despite widespread, intensive, and highly successful foreign exploration programs carried out by the steel companies, the U. S. was only the third largest iron ore importer in the world.

Belgium and the United Kingdom were first and second, with West Germany lagging slightly behind the U. S. Table I illustrates the growing import trend among steel producing nations by comparing 1932 and 1952. When imports are balanced against exports the U. S. falls even lower on the scale, behind Japan. Imports of ore into the U. S. in 1952 totaled 4.5 million tons, or only 4.64 pct of domestic production. Undoubtedly the percentage will rise in the future, but in 1952 the U. S. depended little on foreign sources, primarily seeking ores of higher grade than mined domestically.

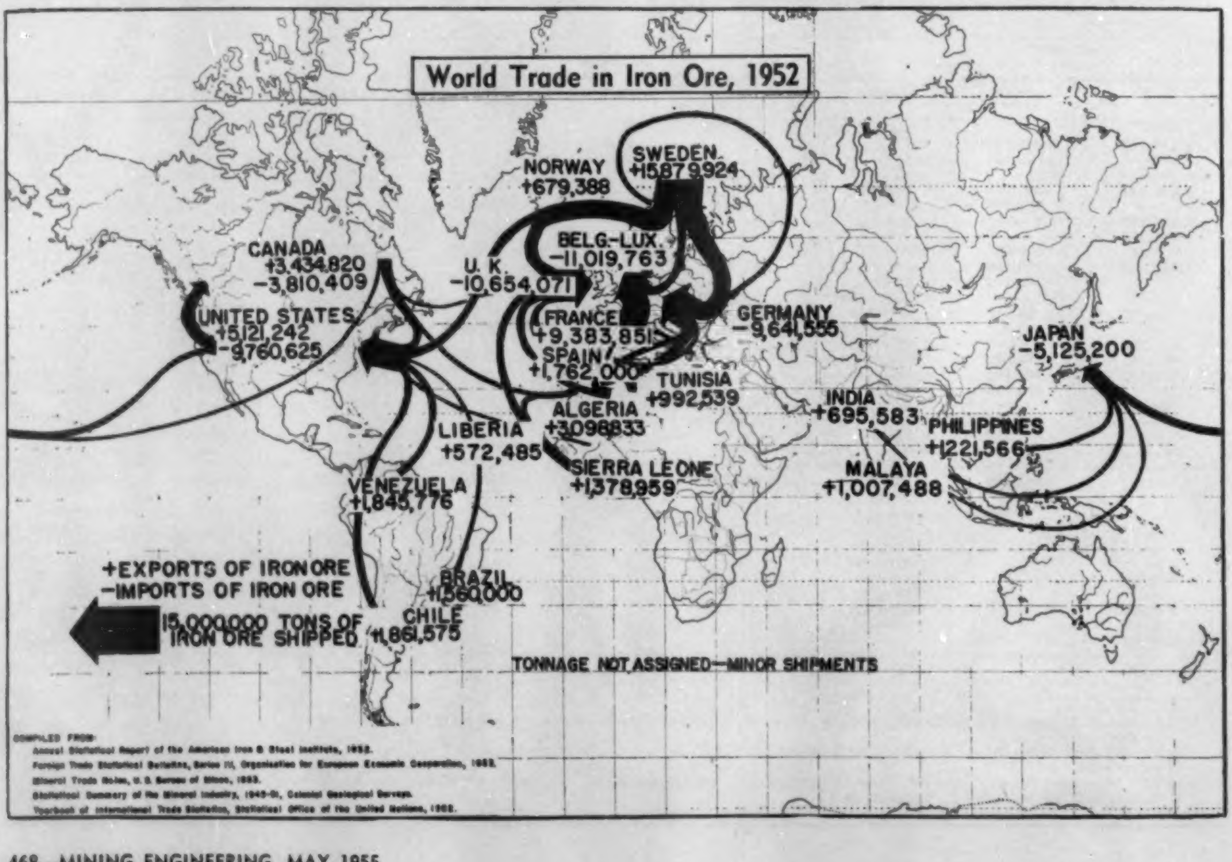
Sweden is the world's largest iron ore exporter, shipping almost 16 million tons and in 1952, of a total production of 17.4 million tons. Some 35 pct went to Germany, 31 pct to the United Kingdom, 13.8 pct to Belgium-Luxemburg, and 13.3 pct to the U.S. Swedish ores were used by the importers to raise the grade of other imported ores as well as of domestic ores.

France is second to Sweden in iron ore exportation, shipping slightly more than 9.4 million tons in 1952. Belgium received 89.3 pct, the U.K., 4.8 pct, and Germany, 4.0 pct. French ore is of considerably lower grade than the Swedish product. Thus, importing French ore usually means importing Swedish ore as well for efficient blast furnace operation.

Third largest exporter in 1952 was the U. S., with essentially all of the shipments going to Canada and Japan. While Canada was the next largest exporter, imports and exports were almost equal. Exports by Canada to the U. K. and Japan were roughly equal, with exports to the U. S. being about one and a half times the total of both. Canadian ore imports were practically all from the U. S. The swapping of ore between the U. S. and Canada is largely a matter of relative mine-plant location in the two countries.

Most of the other iron ore exporters have either insignificant steel industries or none at all. Countries to which ore is exported are determined largely by geography, which in turn affects the commercial ties established. Algeria, although part of France, exports to the United Kingdom, Belgium-Luxemburg, and Germany, but not to France. The low grade Algerian product is not needed by France, and the other countries are within short water haul.

Chile exports to the U. S. principally because U. S.



capital, from Bethlehem Steel Corp. specifically, developed the magnetite deposits at El Tofo. Venezuelan ties with the U. S., for years based on petroleum, have now been enhanced by U. S. Steel Corp.'s and Bethlehem's iron ore operations. Venezuelan ore should take on increased importance, particularly in view of declining Chilean productivity.

Spain's shipments to the United Kingdom are based on long-standing commercial ties, while her exports to Germany are indicative of German buying of ore wherever it can be had. The rest of Spain's ore exports are sent in small quantities to several countries.

Brazil ships largely to the U. S. but several other countries, including Germany, Canada, and the Netherlands, receive small amounts. Sierra Leone exports to the United Kingdom and Western Germany, while the Philippines entirely and India and Malaya in large part are suppliers of Japan. Tunisia sends ore to the United Kingdom, Italy, and the Netherlands. Spanish and French Morocco ship to Germany, the United Kingdom, and the Netherlands. Shipments from Norway go largely to Germany, but some 40 pct of the Norwegian total in 1952 went in small amounts to a number of European countries. Liberian exports go to the U. S. only, Goa to Japan and Germany, and Belgium-Luxemburg and Austria mainly to Germany.

The ratio of imports to domestic production in the U. S. was small in 1952. On the other side of the ledger, the United Kingdom imported an amount equal to 60 pct of its native output, with half the tonnage coming from Sweden. The rest was drawn from French possessions in Africa, Britain's own Sierra Leone, Spain, Spanish Morocco, and Canada. Of the 7.13 million tons produced by Belgium and Luxemburg in 1952, Luxemburg was responsible for 7 million tons. Both countries imported a total of more than 8 million tons of French ore, along with 2 million tons of Swedish ore to sweeten blast furnace charges.

Germany, producing 15 million tons of relatively low grade ore, had to import 10 million tons of which 5.5 million tons were from Sweden. Germany dealt with 21 countries for ore, in addition to Sweden. Amounts ranged from 670,000 tons from Spain to 22,352 from Turkey. A number of countries contributed a total of 75,000 tons.

Japan imported about 1.3 million tons from the U. S. and the same amount from the Philippines, and about three quarters of a million tons from Malaya, Canada, and India. A small quantity also came from Portuguese India (Goa).

While major U. S. steel producers are emphasizing exploration, other steel producing nations import large percentages of total ore consumed. Much of the ore has to be of the high grade Swedish type to insure efficient blast furnace operation.

INTERNATIONAL MINERAL TRADE SERIES

Part II

World Trade in Manganese Ore

by John D. Ridge and Betty S. Moriwaki

WITH the exception of the Soviet Union, manganese exporting nations have little or no steel industry. Statistics for Russia are not reliable. India, largest manganese exporter in 1952, produced about 1.66 million tons of steel, the Gold Coast none, and the Union of South Africa, 1.4 million tons. Other nations sending manganese to the U. S. produced practically no steel. The U. S. is in about the same position relative to manganese as is Germany to ore. Both must scrape every possible source. India furnishes about 38.5 pct of U. S. needs, but nine countries sold 50,000 tons of ore containing at least 35 pct manganese to the U. S. in 1952.

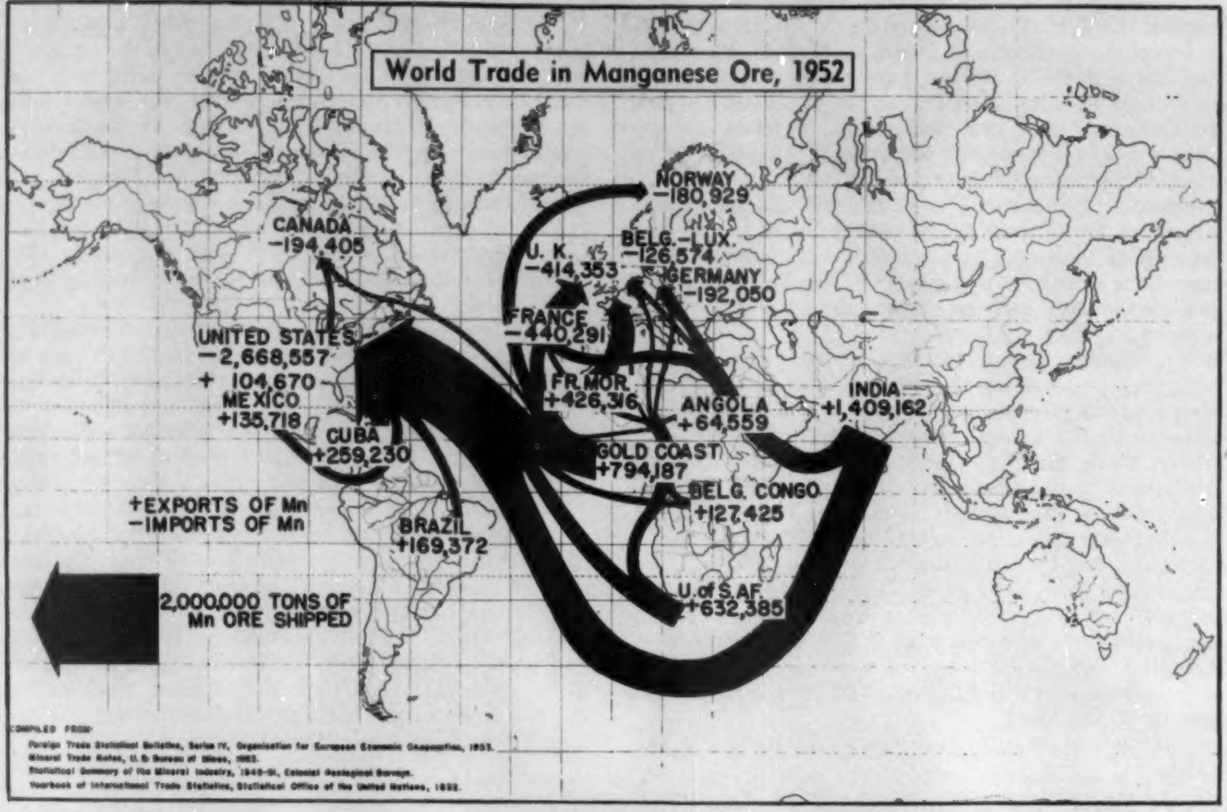
The U. S. depends on foreign suppliers for more than 95 pct of its manganese consumption. Some 64,000 tons of ferromanganese were also imported in

Table II—World Trade in Manganese Ore,* Tons

1952

		Importer								
Exporter	Total	U. S.	France	U. K.	Canada	Germany	Norway	Belg.-Lux.	Misc.	Europe
India	1,409,162	1,028,289	—	139,512	13,954	148,135	—	45,979	33,293	(336,626)
Gold Coast	794,187	368,068	—	180,000	63,112	—	153,162	—	29,845	(333,162)
U. of S. A.	632,385	319,719	63,933	94,841	7,529	43,921	—	60,124	42,318	(262,819)
Fr. Morocco	426,316	85,316	340,358	—	—	—	—	—	—	(340,358)
Cuba	259,230	259,230	—	—	—	—	—	—	—	—
Brazil	169,372	169,372	—	—	—	—	—	—	—	—
Mexico	135,718	135,718	—	—	—	—	—	—	—	—
Bel. Con.	127,425	54,144	—	—	—	—	27,767	10,192	35,322	(37,959)
U. S.	104,670	—	—	—	73,394	—	—	—	31,276	—
Angola	64,559	64,559	—	—	—	—	—	—	—	—
	4,123,024	2,668,557	404,291	414,353	194,405	192,050	180,929	126,574	172,096	(1,310,924)
					1932					
			Japan							
Russia	401,000	56,000	7,000							330,000
India	311,000	2,000	43,000							266,000
Gold Coast	52,000	25,000	—							27,000
Brazil	31,000	22,000	—							9,000
China	20,000	—	20,000							—
Cuba	7,000	—	—							7,000
D. E. Indies	7,000	—	2,000							5,000
Puerto Rico	2,000	2,000	—							—
	831,000	114,000	72,000							646,000

U. S. Production 1952 — 115,379 Tons.
* Containing 35 pct or more manganese.



1952. It has emphasized the need for serious work in production of usable manganese from low grade ores and from slags in this country and development of large-scale producers in this hemisphere.

There are some departures from the general relationship between the amount of steel produced by a country and the quantity of manganese it imports. Canada and Germany imported almost equal amounts of manganese ore in 1952, but German steel production was about 17 million tons and Canada's only 4 million. Canada, however, is a large exporter of ferromanganese, mainly to the U. S. Germany imports considerable ferromanganese from Norway, which also serves to explain Norway's large manganese imports. Abundant electric power in that country makes it profitable to convert manganese ore to ferroalloy for export to the U. S. and Germany.

Germany draws most of its manganese ore from India and the Union of South Africa. The United Kingdom depends on Commonwealth nations, the Gold Coast, India, and the Union of South Africa. Belgium-Luxemburg obtains ore from India and the Union of South Africa, and probably imports some ferromanganese from Norway.

Iron ore and manganese can be attracted from any part of the Free World with little trouble to a major steel producing country whose supply of solid fuel is still substantial. Steel production by major manganese producers, excepting Russia, is still so small that it offers no threat to continued ore exportation.

The International Mineral Trade Series—

In this issue MINING ENGINEERING presents the first parts of a continuing series of articles on movement between nations of the vital minerals, the essential metal raw materials.

Additional articles in the series will appear in forthcoming issues. The complete series includes the following subjects:

- **Introduction: Factors Controlling International Trade in Metal Raw Materials—John D. Ridge**
- **Part I: IRON ORE—J. D. Ridge and B. S. Moriwaki**
- **Part II: MANGANESE ORE—J. D. Ridge and B. S. Moriwaki**
- **Part III: CHROMITE—J. D. Ridge and B. S. Moriwaki**
- **Part IV: NICKEL Concentrates and Metal—J. D. Ridge and B. S. Moriwaki**
- **Part V: COPPER Concentrates and Metal—J. D. Ridge and R. C. Barwick**
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REPRINTS: No requests for reprints will be filled until the completion of the series. At that time an announcement will be made in MINING ENGINEERING as to availability of the complete series of articles.

Handling Difficult Flotation Froths

by W. H. Reck

INCREASING use of flotation in modern beneficiation has resulted in a variety of froth handling methods. Froth must be handled mechanically to maintain common floor elevation, because pure gravity flow, stage to stage, makes for multiple level machine installations with higher first cost and less convenient operation.

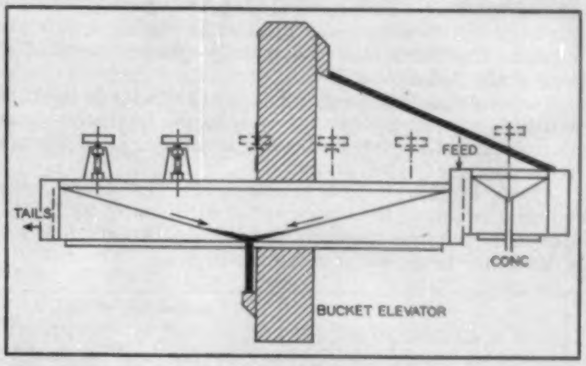
W. H. RECK is Product Manager, Wemco Div., Western Machinery Co., San Francisco.

Which froth-handling method to use is not a serious question in sulphide flotation where alcohol, pine oil, and cresylic acid frothers are used. However, in the flotation of nonmetallics such as barite, fluorspar, manganese, and cement, large amounts of mineral usually are floated, using fatty acid and soap type reagents. Since these reagents have excessive frothing as well as collecting properties, frothing balance is often difficult to maintain.

BUCKET ELEVATOR—Froth is collected by launder and goes to the feed entry of the elevator, below the floor. The bucket goes to the next treatment stage by gravity flow.

The outstanding advantage is high efficiency of conveyance.

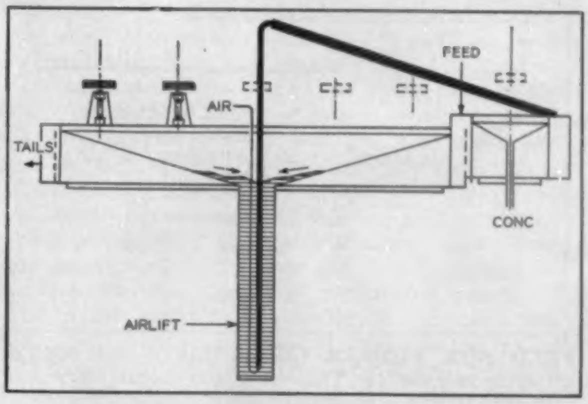
The six most important disadvantages are: 1) Bulky installations; 2) Awkward maintainance; 3) Sub-elevation and head room required; 4) Expensive installation; 5) Substantial space required; 6) Cascade action within the bucket elevator usually aggravates frothing.



AIR LIFT—The sketch shows collection of rougher froth in a five-cell launder whose lower apex section forms the submerged section for the air lift. The upper portion of the air-lift tubing is raised to allow gravity launder flow to the next stage.

The air lift, has at best, three advantages: 1) Extreme simplicity of principle; 2) Ease of construction; 3) Absence of moving parts.

At least four disadvantages of the air lift are: 1) Deep sumps are required; 2) Head room to permit gravity delivery; 3) Efficiency is low, about 15 to 40 pct; 4) Inherent aerating characteristics are generally undesirable.



VERTICAL CENTRIFUGAL SAND PUMP (Independent Type)—One of the earlier adaptations for flotation closure, the pump is a completely separate installation.

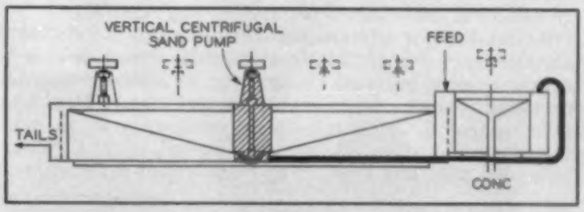
This vertical pump has three advantages: 1) Runner mounted on vertical shaft prevents air locking; 2) Nominal floor space required; 3) One level operation.

The principal disadvantage of this machine is that the insufficient head of its feed chamber does not allow for counter-balanced installation. Repair access may be unfavorable. (Not illustrated.)

VERTICAL CENTRIFUGAL SAND PUMP (Built-in Type)—For compactness and simplicity the pump sump can be built into the froth launder. The runner case is bolted to the bottom of the sump.

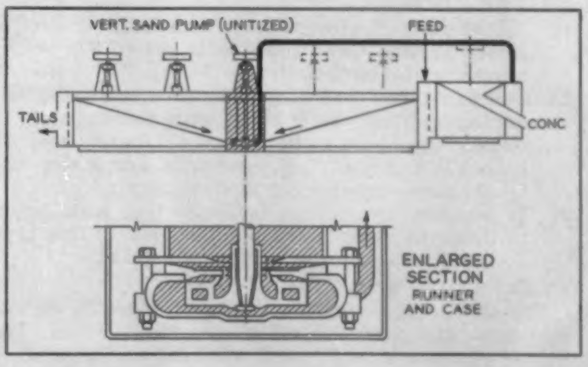
This pump has four advantages: 1) Runner mounted on a vertical shaft prevents air locking; 2) Design permits counter-balanced system; 3) Installation is single level; 4) Minimum floor space required.

Although feed head disadvantage has been remedied in this design of vertical pump, convenience of repair is not favorable.

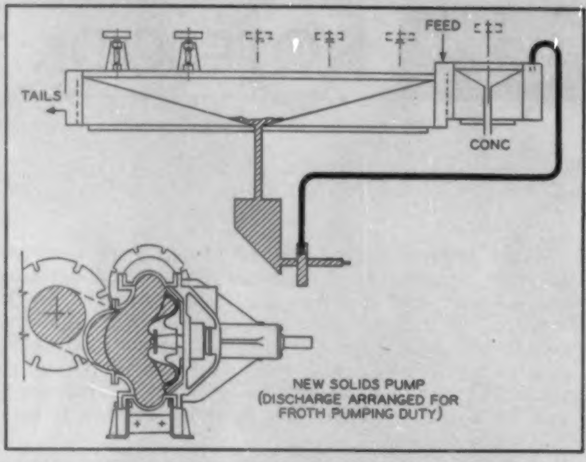


VERTICAL CENTRIFUGAL SAND PUMP (Integral Type)—The pumping unit differs from the previous arrangements in that the entire mechanism is integral, and is not attached to the sump. This makes for economy in repair or replacement, since the entire assembly unit can be lifted out and a new one brought in.

This type has five advantages: 1) Runner mounted on vertical shaft prevents air locking; 2) Minimum floor space: 3) One level operation; 4) Counter-balanced conveying; 5) More favorable maintenance than other type vertical sand pumps.



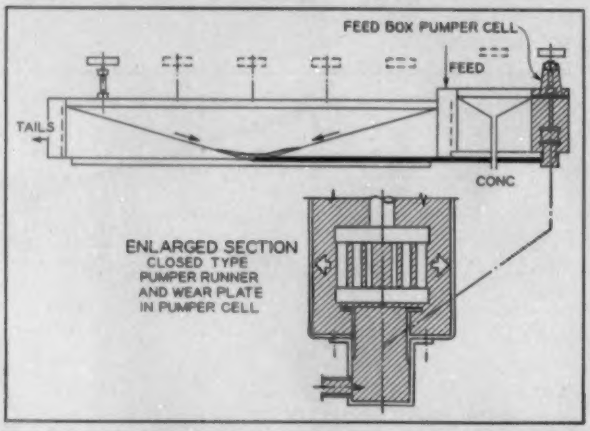
Flotation



HORIZONTAL CENTRIFUGAL SAND PUMP—This is perhaps the most common method of closing a flotation circuit. The sand pump is usually placed some 10 ft below the flotation floor.

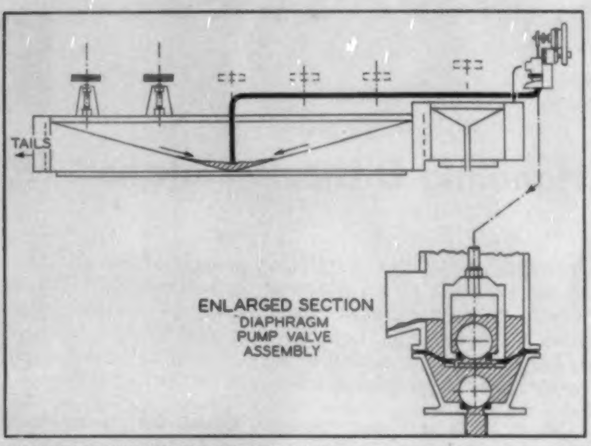
Two outstanding advantages are: 1) It lends itself to multiple row, large tonnage systems particularly where normal metallic type froths are involved; 2) It offers a wide choice of types and sizes.

There are three disadvantages: 1) The usual sump volume required uses substantial mill space; 2) Its use normally imposes a second level of operation; 3) It has a tendency to air lock on froth pumping.



FEED BOX PUMPER CELL—This is the simplest pumping mechanism. The pump is at the delivery point rather than at the material source. The pump impeller shown is of the close type, and of high capacity.

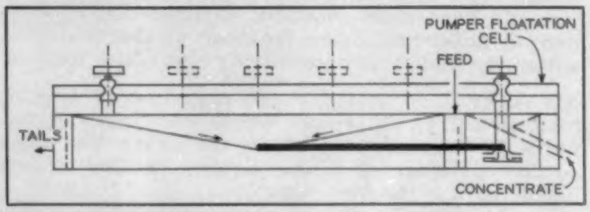
At least eight advantages can be listed: 1) Extreme simplicity of design; 2) No close fitting runner case to make for possibility of air locking; 3) Runner mounted on vertical shaft also prevents air locking; 4) Minimum floor space; 5) Machine space occupancy is in non-interfering location; 6) One level operation; 7) Counter-balanced pumping system; 8) Convenient maintenance.



SUCTION DIAPHRAGM PUMP—The pump is mounted at the delivery point and the suction line is installed to the apex within the five-cell froth launder.

The three principal advantages are: 1) Positive type displacement; 2) Minimum floor space required; 3) One level operation.

Disadvantage of the diaphragm pump is low volumetric capacity for size of machine. Also it is the only non-self priming unit described in this article.



SINGLE IMPELLER PUMPER CELL—Pumping is by inverted open type impeller and draft tube arrangement. Aerating and pulp teetering functions, as well as pumping are handled by the one impeller. Aerating and pumping are complementary, thus an increase in pulp pumping duty automatically decreases aeration, and vice versa.

The single impeller cell has six advantages: 1) Simplicity of design; 2) No runner case to envelop air; 3) Runner is mounted on vertical shaft to minimize possibility of air locking: 4) No floor space chargeable to feed pumping; 5) One level operation; 6) Counter-balanced pumping.

Two disadvantages are: 1) Pumping function may interfere with maximum aeration; 2) Overhead type feed entry to impeller reduces pumping lift, thus affecting launder closure slope.

The **Double Impeller Pumper Cell** provides the advantage of separating the aeration and pumping functions to prevent failure of either. The latest development in this general type, the **Triple Impeller Cell** gives all the advantages of the single and double impeller types, plus the provision of a suitable impeller for each function: aeration, pulp teetering, pumping.

USEFUL HINTS:

1) Install all froth closure units with high volumetric safety factors. Good practice is 200 to 300 pct of normal of calculated.
2) For horizontal centrifugal pumps it is usually advantageous to arrange pump with discharge at "12 o'clock" position rather than at the normal "9 o'clock" location. Top discharge eliminates the troublesome case pocket that causes air lock.
3) If possible, use counter-balanced type installation in order to avoid extra pumping head. This type installation also prevents product spillage.

EVALUATION AND CONCLUSION:

The air lift method is practically excluded by its low efficiency and harmful effect on most froths. The bucket elevator is pretty well ruled out on the grounds of cost, mill space involved and its tendency to aggravate frothing. The suction diaphragm pump is satisfactory in small tonnage circuits, particularly with high ratios of concentration.

The four methods of flotation closure which are most suitable are:

1) The Horizontal Centrifugal Sand Pump—for large tonnage, where multiple machine flotation products are combined to one pump installation.
2) The Feed Box Pumper Cell—for all single row flotation closures, especially where large bulk and difficult handling are involved.
3) The Triple Impeller Flotation-Pumper Cell, and the Vertical Centrifugal Sand Pump (integral pump construction)—for all single row, average duty flotation closures, regardless of size.

An Agglomeration Process For Iron Ore Concentrates

by W. F. Stowasser

A downdraft traveling grate process to agglomerate pelletized iron ore concentrates has been successfully demonstrated in a pilot plant at Carrollville, Wis.

Work there followed several years of development in the Allis-Chalmers Mfg. Co. laboratories, and the pilot plant phase was carried out in cooperation with Arthur G. McKee & Co., consultants and engineers to the iron and steel industry. End result of the process is conversion of iron ore concentrates into a form which can easily be transported and smelted in the blast furnace.

Process Description

The first of two process steps incorporates the art of balling and prepares the concentrates for burning. The second step consists of burning the green balls on the grate machine to the hardness required for shipping and handling purposes and for reduction in blast furnaces, see Fig. 1.

Facilities are provided at the pilot plant to receive carload quantities of concentrate. The concentrates are loaded into a 50-ton bin direct from railroad cars. Because of the variable moisture content of the concentrates after shipment in an open railroad car it is necessary to repulp and refilter the concentrates to maintain a uniform and proper moisture content for the balling operation.

Concentrates are conveyed to slurry tanks, and the slurry, at 50 to 60 pct solids, is pumped to a 4x4-ft drum filter. The filter provides feed of uniform moisture to the plant. Magnetite concentrates are normally filtered to produce a cake containing about 10 pct moisture, a necessary requirement for the following balling operation.

The filtered concentrate is conveyed to a rotary bin table feeder which acts as a surge bin for the filter cake and delivers a steady flow of concentrates to the balling drum.

It is often desirable to make additions to the concentrates as they are fed to the balling drum. These additives, such as bentonite, increase the strength of the finished green pellet and improve ballability of the concentrate. A vibrating feeder supplies additive to the feed belt, and the additive is mixed with the concentrate in the balling drum.

The balling drum, shown in Fig. 3, is 8x3-ft diam. An oscillating cutting bar maintains the lining in the drum by trimming off the buildup of excess concentrate as it forms. The drum is operated in closed circuit with a 1x4-ft rod-deck vibrating screen. Undersize pellets or seed pellets from the screen are returned to the balling drum until they grow to the desired size.

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Size of pellets is controlled by the opening in the screen deck. The formation of pellets in the balling drum is affected by many variables. Some of these are: the size distribution of the feed, the particle shape of the concentrate, the feed rate to the drum, the moisture in the concentrate, the speed of rotation of the drum, the slope of the drum, and the type of trimming obtained with the cutting bar. In this process, attempts are made to control the pellet size within the limits of ⅜ to ⅝ in. diam.

The screened oversize pellets are conveyed under a coal feeder where sufficient powdered coal is added to the belt to produce desired results in the burning process. The top size of the coal successfully used has been 20 mesh, and anthracite was used in the test program. Fig. 4 illustrates the vibrating screen and the coal feeder. The pellets and free coal are conveyed together to the 5x3-ft diam coal reroll drum that rolls the coal onto the surface of the pellets. This drum is also equipped with a cutting bar.

The prepared pellets, containing bentonite, water, and surface coal, are elevated to the traveling grate, which consists of a continuous strand of 37 pallets. Each pallet, with a grate bar area 2 ft wide by 1½ ft long, has 14-in. high side plates, Fig. 5.

Feeding and distribution of the green balls to the grate is handled by a short conveyor which oscillates back and forth across the 2-ft width of the grate. An adjustable vertical plate located several inches in front of the head pulley of the oscillating conveyor controls the height of the bed and levels the moving bed of pellets. This method of feeding prevents segregation of various size pellets as well as fines and produces a uniform, permeable bed.

The pallet train moves under the furnace and across four windboxes, located beneath the pallet frames, see Fig. 2. As the green pellets are deposited on the grate, partial drying of the pellets begins over a 2-ft long updraft windbox. The low temperature air reduces the moisture in the pellets in the lower level of the bed and this operation is essential to prevent sagging of the bed during later stages of the process. The air used for this drying is recuperated from cooling the pellets on the grate, and supplemental heat, required for starting the process, is obtained from an auxiliary burner.

The pellets are then moved by the grate into the furnace and over an 8-ft windbox, designated as the downdraft waste windbox. Products of combustion are exhausted from this windbox to atmosphere.

The furnace, shown in Fig. 6, is constructed with three chambers to provide downdraft drying, preheating, and ignition, respectively, to the pellet bed as it passes through. Overall length of the furnace is 5.57 ft; however, the exterior wall ends may be moved to reduce the length and also adjusted to obtain the bed height desired.

The drying, preheating, and ignition sections of the furnace are supplied with medium temperature

The Transactions papers appearing in Mining Engineering during 1955 will subsequently appear in AIME Transactions Vol. 202 and may be permanently referenced to that volume.

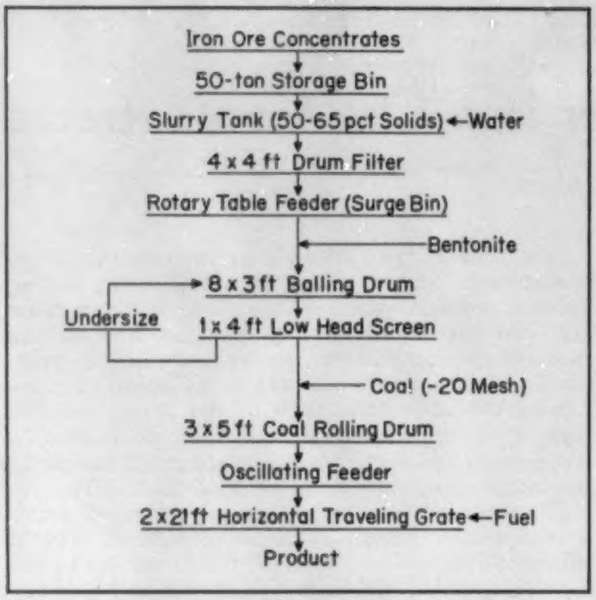

Fig. 1—Flowsheet of agglomeration process.

air recuperated from the windbox following the waste windbox, designated as the recuperation windbox. These furnace sections are equipped with burners to raise the temperature of the recuperated air to that required by the process.

The bed of pellets passing through the furnace is dried and preheated and the surface layer of pellets ignited by downdraft gas flow. Burning progresses through the bed of pellets to the grate bars. The pellets below the high temperature zone in the bed are preheated and dried while those above are cooled. The *burn through* occurs over the recuperation windbox, approximately 3 ft in length.

The gas temperatures from the grate are a maximum at the point of burn through, and this gas is recirculated to the furnace.

The final stage in the process is cooling the pellets over the cooling windbox. The purpose of this windbox, which is about 3 ft long, is to extract the remaining sensible heat from the bed of pellets. This heat is recirculated for updraft drying purposes.

The burned pellets, discharged over a grizzly deck at the end of the machine, are conveyed to a screen tower outside the pilot plant building, where a separation is made over ¼-in. and 8-mesh screens.

Operational Results

The product obtained from the grate is shown in Fig. 7. A pallet is about to discharge the product which averages from 90 to 96 pct +⅜ in. The strength of the product is determined by revolving a 50-lb sample of +⅜-in. pellets in a standard ASTM coke drum at 24 rpm for 100 revolutions. The percent −10 mesh of the screened product after tumbling averages about 10 pct.

Fuel requirement for burning magnetic pelletized concentrates varies from 700,000 to 800,000 Btu per long ton of product. Approximately one-third of the fuel is propane gas consumed in the burners, and two-thirds solid fuel in the bed of pellets.

Capacity of the grate is about 3 LTph at an average speed of 4 to 6 in. per min, depending upon the bed height.

Suction in the waste, recuperation, and cooling windboxes ranges from 3 to 4 in., 3 to 5 in., and from 2.5 to 3 in. water gage, respectively, and the **pressure** in the updraft windbox is about 3.5 to 4 in. water gage.

Temperature of the recuperated air from the recuperation and cooling windboxes ranges from 600° to 800°F and 300° to 400°F, respectively, depending upon the operation. The ignition temperature is maintained at 2300° to 2400°F. The temperature of the waste gas from the waste windbox ranges from 200° to 275°F.

Summary

The downdraft traveling grate process to agglomerate pelletized iron ore concentrates has been successfully demonstrated in the pilot plant phase of this development. The product obtained from these tests indicates the strength to be sufficient to withstand transportation and handling to the Lower Lake ports. The fuel consumption, as shown, results from the effective recuperation of the sensible heat from the process. The output was about 2 LTph per sq ft of grate area. This tonnage result is obtained for the process by including the grate areas, which are utilized to recuperate the sensible heat from the product.

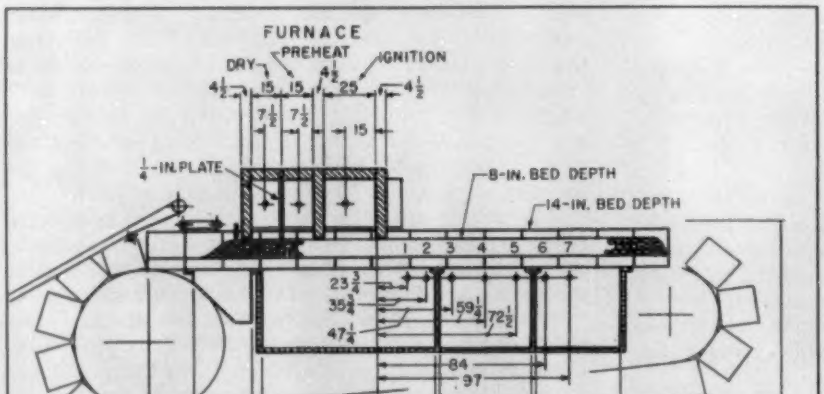

Fig. 2—A sketch of the traveling grate showing windbox locations. All dimensions are in inches.

Pictures from pilot plant show balling, sizing, and heat treating steps of traveling grate agglomeration process for iron ore concentrates.

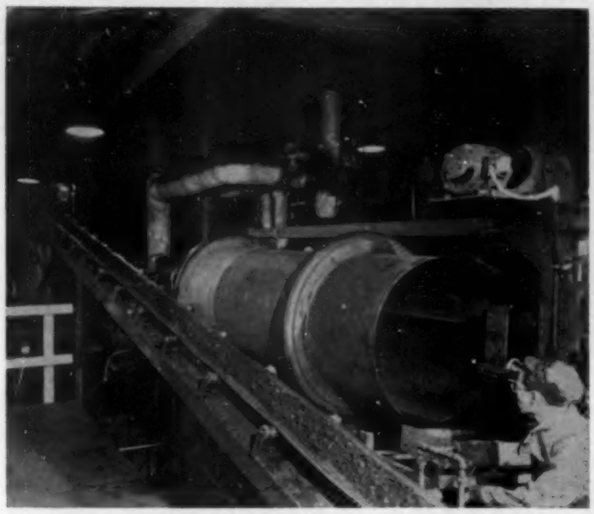

Fig. 3—Balling drum operation. Filtered concentrates on conveyor in foreground are discharged into table feeder.

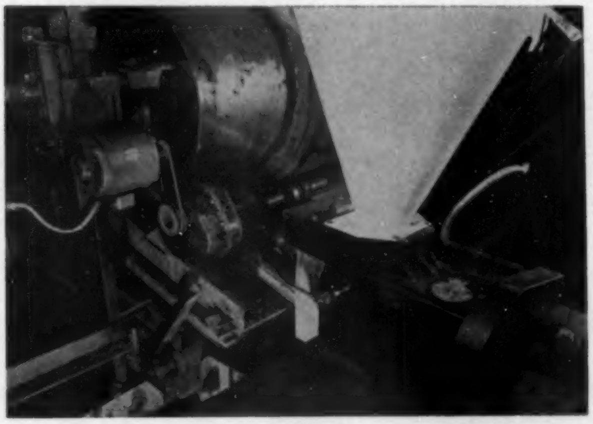

Fig. 4—The Low-Head vibrating screen sizes pellets from balling drum. Omega coal feeder in foreground adds fine coal to sized pellet conveyor.

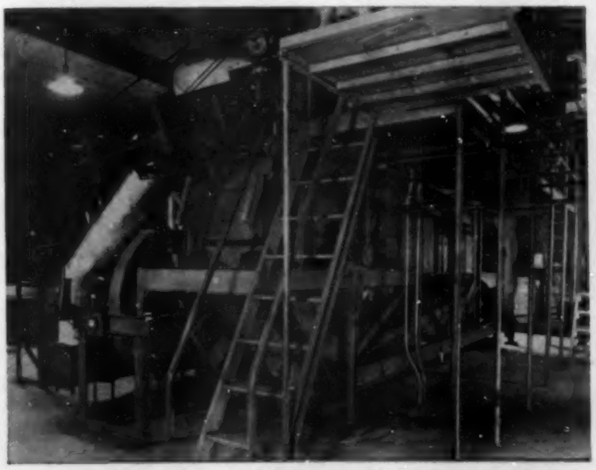

Fig. 5—Drive end of traveling grate. Conveyor elevates pellets from coal reroll drum to grate.

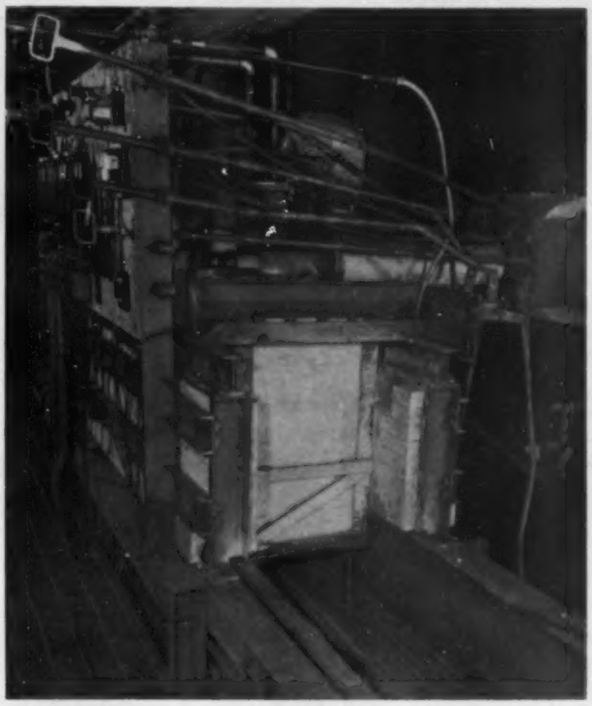

Fig. 6—Traveling grate furnace and instrument control panel. Pellets are visible in foreground.

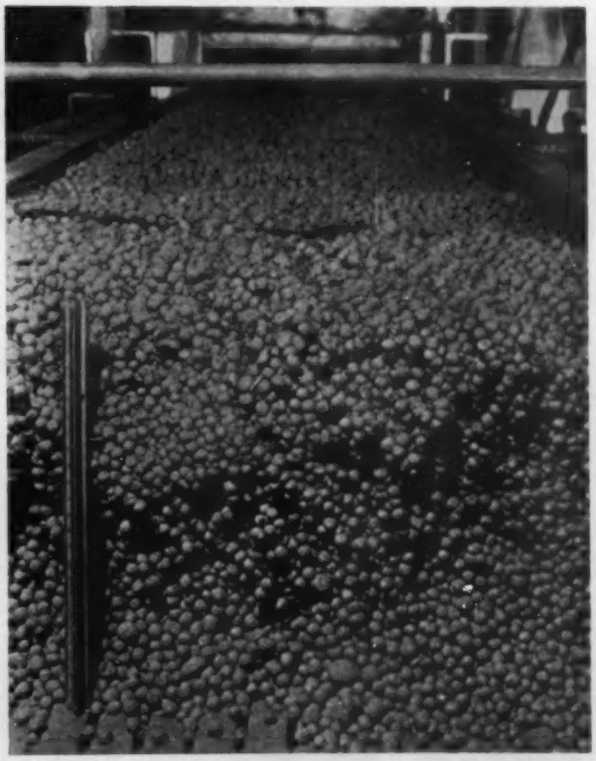

Fig. 7—Burned pellets discharging from traveling grate. These pellets are sized over a grizzly, conveyed to a screen tower, and separated over ¼-in. and 8-mesh screens.

Quantitative Use of X-Ray Diffraction for Analysis Of Iron Oxides in Gogebic Taconite of Wisconsin

by R. S. Shoemaker and D. L. Harris

PAST investigations into the possibility of concentrating the low-grade iron ores of the Gogebic Range in Wisconsin have been hampered by the complex association of the constituent minerals. In part the problem arises from the fact that the iron occurs essentially as two minerals, hematite and goethite, having nearly the same chemical composition but exhibiting different physical properties. Individual grains of these minerals are usually so small that the ore must be ground to a size finer than 325 mesh if substantial liberation of the minerals is to be secured. Appraisal of beneficiation tests on this iron ore requires, therefore, some method of determining quantitatively the contents of constituent minerals in the various products of the beneficiation. Because of the chemical similarity of the two iron minerals, chemical analyses do not provide a means of differentiation. Although the minerals are different physically, they are both opaque and friable, and as the ore must be ground to a very fine size for liberation to be secured, quantitative microscopic methods of analysis are extremely difficult at best. In an effort to overcome these analytical problems, a quantitative X-ray diffraction analysis method has been developed at the University of Wisconsin for the research program on iron ore beneficiation.

The X-ray diffraction analysis of chemical compounds of crystalline form has proved of inestimable value for structure studies and rapid qualitative analytical purposes in a number of fields.[1] In some cases X-ray diffraction analysis has been found suitable for quantitative determinations. H. P. Klug[2] found that quantitative procedures for quartz powders when mixed with calcium fluoride were reproducible within ±1.0 pct. Talvenheimo and White[3] reported quantitative analyses of clay minerals to be accurate within 10 pct and also detected 1 pct of bentonite in 99 pct illite. In other investigations,[4-6] powders of quartz and mica have been analyzed quantitatively with accuracies from 1 to 5 pct. A powder of tungsten carbide was analyzed similarly by Redmond[7] and Rooksby[8] reported the determination of small amounts (0.11 pct) of calcium oxide in magnesium oxide.

In the most generally practiced use of X-ray diffraction, traces of the diffracted beam are recorded as lines on a film much as lines of elements are recorded on an optical spectrograph film. As with the spectrograph, the darkness of the lines denotes the amount of the constituent in the sample. If the film is replaced by a Geiger tube assembly and a graphic recorder or a scaling unit, the intensity of the diffracted beam can be registered as a peak on a chart or energy impulses per unit of time on the scaler.

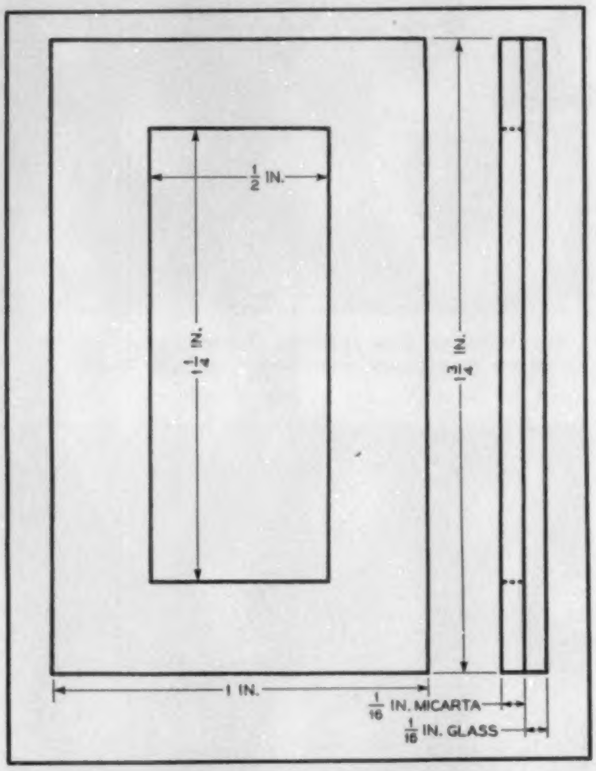

Fig. 1—The X-ray sample holder.

Several methods of quantitative measurement have been investigated and reported in literature. Klug[2] used manual operation of the goniometer and a counting technique to determine the difference in counting rates at the diffracted angle and for the background. In another case[3] the area under the recorded diffracted peak was the basis for the determination. In other instances the height of the recorded diffraction peak above background, measured while the goniometer was moving, has been the basis for the measurement.

The sizes of particles most suitable for diffraction techniques are reported in the literature as follows: for tungsten carbide a maximum of 40 microns[7] and for quartz a maximum of 5 microns.[4] Very fine sizes of crystals are known to cause a broadening of the diffused beams; hence some workers have set a lower limit of 0.1 micron for quantitative results. Guinier[10] has indicated that broadening of the diffracted X-ray beam is not appreciable for crystallites larger than 0.02 to 0.03

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micron in diam. However, Birks and Friedman[11] determined particle sizes by line broadening for particles in the size range of 0.005 to 0.1 micron. These data indicated the possible application of diffraction analysis to the problem at hand, as the iron ores had to be processed at particles sizes in a range between the above-mentioned extremes.

Ores and Equipment: The iron ore used in this investigation was part of a number of taconite samples taken from a formation in the area near Montreal, Wis., by the U. S. Bureau of Mines.[9] The formation consists of five longitudinal members, the Plymouth, Yale, Norrie, Pence, and Pabst. The five members were sampled in four trenches, *A*, *B*, *C*, and *E*, cutting across the formation. Only material from trench *E* was available for this investigation.

The taconite is composed of ferruginous slate or chert, the ore minerals being mainly hematite and goethite. The gangue content consists chiefly of silica. The U. S. Bureau of Mines reported that major minerals in the formation are hematite, goethite, magnetite, limonite, and quartz; minor minerals are siderite, psilomelane, pyrolusite, rhodonite, feldspar, and other iron silicates. However, only hematite, goethite, quartz, and minor amounts of magnetite and siderite were found in the samples used in this investigation. Chemical analyses of the five members are given in Table I.

Table I. Head Sample Analyses of Taconite Members

Member	Iron, Pct	Silica, Pct
Plymouth	27.7	55.8
Yale	28.3	52.6
Norrie	27.6	52.0
Pence	32.7	48.8
Pabst	30.3	50.4

A General Electric Model XRD-3 diffraction unit with spectrogoniometer and chart recorder was used for the X-ray diffraction measurements. The tube with an iron target was operated at 50 kv and 8 milliamperes. The beam and detector slits, 3.0° and 0.1°, respectively, were used with a manganese filter. Damping and amplitude controls for the recorder and amplifier were set at maximum time constant, C, and maximum sensitivity, No. 1.

Operation of the instrument is as follows. The X-ray beam is directed to the sample by the beam slit and a collimator. As the X-rays are diffracted by the mineral crystals in the sample, they pass through the detector slit and filter into the Geiger tube assembly, which rotates around the sample at 0.2° or 2.0° per min. The energy of the X-rays striking the Geiger tubes activates a Speedomax recorder, through an amplifier circuit, producing a series of peaks on a moving chart. The ordinant of the chart represents the intensity of the diffracted beam in arbitrarily chosen units of hundredths, while the abscissa is calibrated in degrees of the diffraction angle as determined by the Bragg equation, $N\lambda = 2d \sin \theta$. In a homogenously mixed sample of completely unoriented particles the amount of surface that is exhibited by any mineral should dictate the height of its diffraction peaks drawn on the chart.

Since qualitative X-ray analyses revealed the major minerals of each taconite member to be hematite, goethite, and quartz, the standard samples were established on that basis. The goethite used came from Tuscaloosa County, Alabama. The chemical analyses of the mineral were: insoluble, 5.4 pct; water, 11.9 pct; iron, 54.3 pct; and alumina, 5.0 pct. Water content was determined by ignition at 980°C. (The theoretical percentage of water in pure goethite is 10.15 pct). Pure goethite ($Fe_2O_3H_2O$) contains 62.9 pct iron; hence the mineral sample contained 86.3 pct goethite by calculation. The X-ray diffraction pattern indicated a small amount of quartz and other unidentified broad peaks for the impurities.

The standard hematite sample came from the Vermilion Range in Minnesota. Chemical analyses showed 1.19 pct insoluble and 67.1 pct iron. The theoretical percentage of iron in pure hematite is 70 pct; hence the mineral sample contained 95.9 pct hematite (Fe_2O_3) by calculation. The X-ray diffraction pattern indicated no lines other than those for hematite.

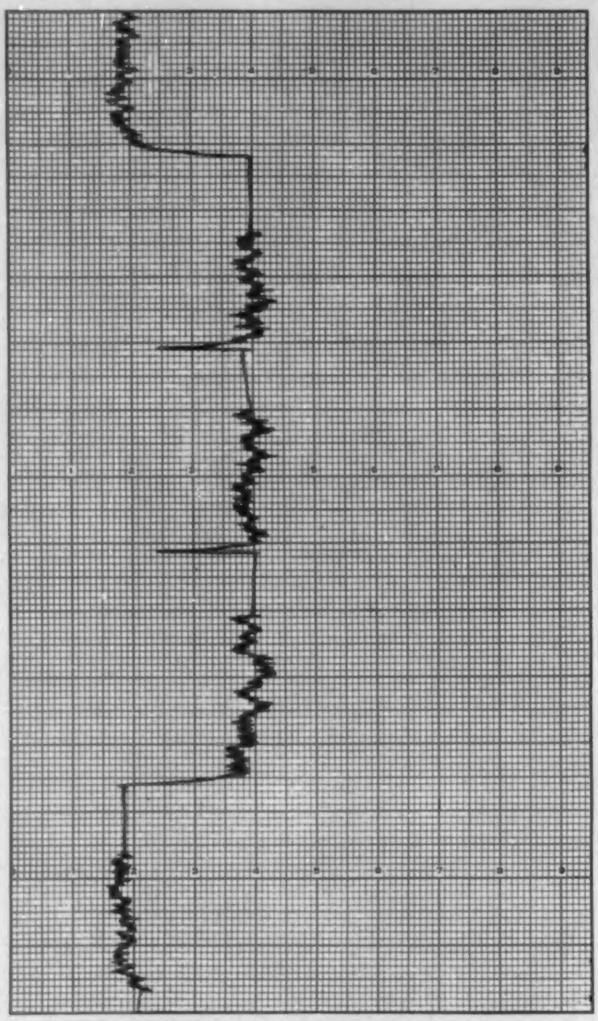
The procedure was standardized for the mineral samples, goethite and hematite, which differed in origin from the taconite samples investigated. It was assumed that the difference in origin did not affect the results appreciably, as no direct check was available for comparison with the diffraction analyses. It has been suggested by Bailey[12] that the diffraction angles for iron oxides may possibly be affected by the presence of impurities substituted in the lattice for iron (aluminum, for example) and that the intensities of the beams may be characteristic of the origin of the material. For the latter reason, use of standard samples from a source different from that of the material to be tested is offered with reservations.

Procedure: The silica contents of the taconite samples were determined as the percentage of insoluble after fusion of the samples. Percentage of iron was determined by volumetric titration with potassium dichromate in the presence of sodium diphenylamine sulphate indicator.

Approximate 1000-lb lots of each member of the taconite formation, −1 in. size, were split in a Jones splitter to obtain 60-lb samples. The latter were crushed to ½ in., split again, and then crushed to 8 mesh and stored dry. Small head samples were pulverized to −100 mesh in a Braun pulverizer having *hard-faced* plates to minimize the contamination by abraded iron. A mullite mortar and pestle were used to grind all the samples to 400 mesh and mix them for the X-ray tests.

The sample mount was made from a microscope slide and a micarta spacer, 1¼ x ½ x 1/16 in. deep, inside dimensions, Fig. 1. The powdered material was packed gently into the tray without cement or filler and leveled with the edge of a glass slide. Various types of sample mounts have been used by investigators, but difficulties such as preferential orientation of mineral grains and inaccurate background readings, inherent to all of them but the tray type, precluded their use in this investigation.

Diffraction measurements for this work were first made on a series of standards made from various mixtures of goethite, hematite, and quartz containing 10, 25, 50, 60, 70, and 80 pct quartz. All standards were prepared in the same manner with regard to grinding, screening, and mounting. After a few preliminary tests, made by the scanning technique on the diffraction unit, a different procedure was developed which furnished better accuracy; background readings were obtained by operating the diffraction unit (including recorder) at fixed angle settings, chosen at a few degrees from the diffraction peaks. After 3 min of recording of the background, the goniometer was shifted to the



chosen diffraction angle and a 3-min reading was obtained for each of 3 positions of the sample mount. A second background reading of 3 min was then made at the same angle as the first background reading. The recorder readings (0 to 100 maximum), or traces, were averaged graphically, and the latter values were averaged for the two background readings and for the three peak readings. (Instantaneous readings of background or diffraction intensities could vary as much as ±5 units for any given intensity.) Differences between background and peak readings were noted as the intensities corresponding to the sample composition and the given diffraction peak. An example of this method of recording the diffraction peaks is shown in Fig. 2 for the 41.8° line of hematite. In contrast to this, a chart showing the scanning technique is given in Fig. 3. The 41.8° line of hematite is marked with an X.

The use of graphic averages of recorded traces has the advantage of indicating shifts in background intensities and shifts in operating voltage of the diffraction unit for which the equipment cannot compensate. Measuring the intensities at fixed positions of the goniometer allows more accurate average intensity values than if the readings were taken instantaneously as the goniometer moves.

Goethite intensities were determined at 26.6° and the corresponding background at 25.2°. Hematite intensities were determined at 41.8° and 69.5° and the corresponding backgrounds at 40.0° and 67.0°. All diffraction angles are noted as goniometer angles, which are equal to twice the Bragg diffraction angle (θ), and were determined empirically from previous scanning data. Preliminary investigations and trials indicated the foregoing to be satisfactory for the minerals and percentages to be determined.

Results: The standard samples of goethite and hematite and the taconite samples were analyzed qualitatively by X-ray diffraction according to the scanning technique. Maximal settings were then determined for the diffraction beams for the mineral standards at fixed positions of the goniometer. The latter settings were found lower than the maximal settings indicated by the scanning technique.

The sample results, tests 1-4 in Table II, show a variation of small magnitude, the largest being ±11.5 pct for duplicate measurements for the 41.8° line for hematite. The variations noted for the 69.5°

Table II. Variation in Diffraction Intensity Measurements for the Tray-Type Mount*

Sample	Goethite at 26.6° (2θ)	Variation, Pct	Hematite at 41.8° (2θ)	Variation, Pct	Hematite at 69.5° (2θ)	Variation, Pct
1a	23.3	+0.2	41.9	+0.1	21.2	+0.5
1b	23.2	−0.2	43.9	−0.1	21.0	−0.5
2a	26.6	−3.3	33.5	+11.5	14.5	−5.8
2b	30.5	+3.3	27.5	−11.5	16.3	+5.8
3a	2.7	−8.5	48.6	+0.5	27.4	+4.6
3b	3.2	+8.5	48.0	−0.5	25.0	−4.6
4a	16.0	−4.5	23.5	+1.1	9.2	+1.7
4b	17.5	+4.5	23.0	−1.1	8.9	−1.7

* Samples 1, 2, 3, and 4 contained 45-45-10, 25-65-10, 45-5-50, and 15-25-50 pct hematite, goethite, and quartz, respectively.

Fig. 2 (upper left)—Chart of the diffraction intensity of the 41.8° line of hematite in a sample containing 10 pct quartz, 85 pct goethite, and 5 pct hematite.

Fig. 3 (lower left)—Diffraction chart of the Norrie head sample made by the scanning technique.

line for hematite and the 26.6° line for goethite are approximately half as large. All results reported for this investigation are the average values of three measurements.

A summary of the goethite determinations, based on the measured intensities at 26.6° and background at 25.2°, is plotted vs the percentages of goethite and hematite for given percentages of quartz (10, 25, 50, 60, 70, 80 pct quartz) in Fig. 4. The percentage of goethite is shown to be proportional to the measured intensities. These data indicate that the

Table III. Chemical Analyses and Mineral Compositions of Taconite Members

Member	Chemical		X-ray Goethite	X-ray Hematite	Others		Calculated from Mineral Analysis Fe, Pct
	SiO_2, Pct	Fe, Pct			$FeCo_3$ Fe, Pct	Fe_3O_4 Fe, Pct	
Norrie	52	27.6	38	11.5			31.9
Pabst	50.4	30.3	23.6	22.0	0.6		30.8
Plymouth	55.8	27.7	24.5	16.0			26.6
Pence	48.8	32.7	12.9	21.0	1.9	3.6 to 7.2	28.3 to 31.9
Yale	52.6	28.3	29.1	10.0	1.9		27.1

intensities of the measurements have a linear relationship to composition for various mixtures of quartz, goethite, and hematite. To show more clearly the inverse relationship of the diffraction intensities of hematite and goethite, the curve of Fig. 4 is shown with a negative slope. The goethite standard contained 86.3 pct goethite (calculated) and 13.7 pct impurities. Values plotted in the figure are corrected for the analysis.

The hematite intensities measured at 69.5° and 41.8° are proportional to the percentage of hematite in samples containing fixed amounts of quartz and varying amounts of goethite and hematite. The data are summarized in Figs. 5 and 6 for a series of samples containing 10, 25, 50, 60, 70, and 80 pct of quartz. Measured diffraction intensities are plotted vs the weight percent of goethite and hematite. The plots indicate that the intensities vary appreciably with the percentage of quartz present, particularly for the data obtained at 41.8°, Fig. 3. The latter may be explained by the fact that the hematite line, or diffraction angle of 2 θ, 41.8°, nearly coincides with a goethite diffraction angle and the latter affects the measured intensity of the hematite diffraction measurement. In samples of varying quartz content corresponding to changes in goethite content, for a given percentage of hematite, the measured diffraction intensity of the hematite line would vary with the quartz content. Results of the diffraction analysis using the hematite diffraction angle, 69.5° , Fig. 4, are more consistent and less affected by goethite and quartz contents. In both instances the effects of varying quartz content (and the related goethite content) can be noted in the way the curves of Figs. 3 and 4 generally increase in slope as the quartz content increases.

The intensity measurement in every case is the difference between the diffraction intensity and the background. The background measurement is made at an angle presumed to be free of characteristic diffraction effects for the given minerals. The latter presumption may not be true in every case, but it is believed that the background angles chosen for this investigation are satisfactory.

After the X-ray procedure was standardized for the analyses of the minerals, goethite and hematite, in mixtures of goethite, hematite, and quartz, head

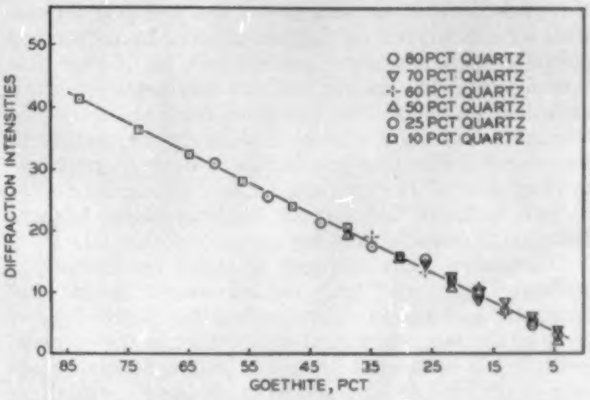


Fig. 4—Diffraction intensities of the 26.6° line of goethite vs percentage of goethite at 80, 70, 60, 50, 25, and 10 pct quartz in mixtures of quartz, goethite, and hematite.

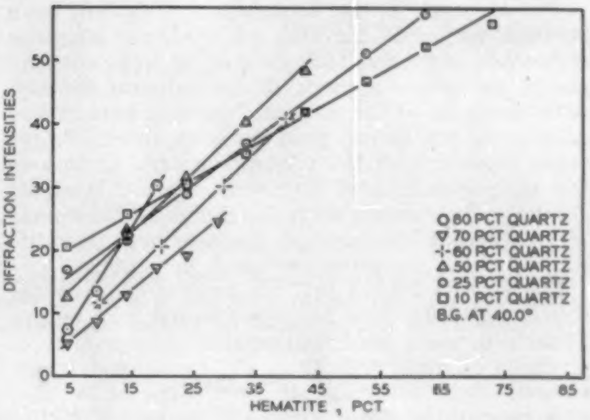


Fig. 5—Diffraction intensities of the 41.8° line of hematite vs percentage of hematite at varying percentages of quartz in mixtures of hematite, goethite, and quartz.

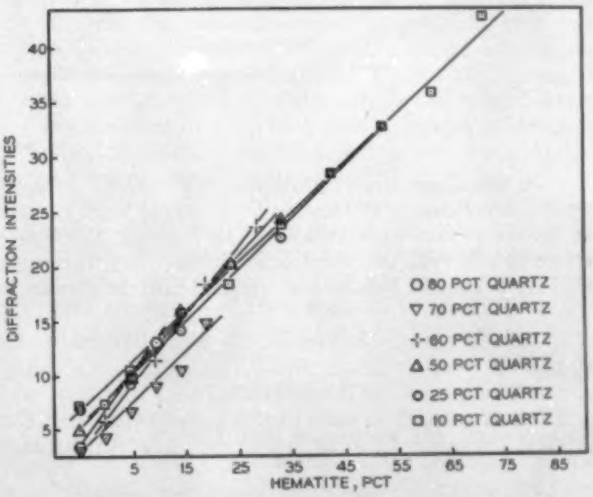


Fig. 6—Diffraction intensities of the 69.5° line of hematite vs percentage of hematite at varying percentages of quartz in mixtures of hematite, goethite, and quartz.

samples of the five members of the taconite formation were analyzed by diffraction. The hematite and goethite contents were determined by X-ray diffraction, and the quartz content was determined by chemical analysis. The hematite contents were determined from the standard plots corresponding to measured diffraction intensities and given percentages of quartz. The goethite contents could be determined without the quartz content being known. Results of the analyses are given in Table III.

Discussion: The mineral analysis by diffraction indicates that the iron oxides consist mainly of hematite and goethite. The calculated percentage of iron in the taconite samples based upon the mineral analyses is compared with the iron contents determined by chemical means to show good correlation. The analyses can be explained as follows. The Pabst, Norrie, and Plymouth members in the main contain only goethite and hematite. The Yale member contains an appreciable amount of iron carbonate (determined by CO_2 analysis) and the Pence member contains iron carbonate and 5 to 10 pct magnetite (the latter determined by magnetic separation and X-ray diffraction).

The accuracy of the determination has not been checked by other methods of analysis. Magnetic separation of the five taconite members has not furnished an accurate check of the mineral content. A rough check of the magnetic mineral content was attempted, but locked grains caused unreliable results. Even though the total percentage of iron in the sample calculated from the mineral analyses checks approximately with the chemical determination, different contents of goethite and hematite could furnish the same total iron percentage

The writers believe that the method of quantitative X-ray diffraction described herein may be applicable in many beneficiation studies, especially to products of sizes finer than 400 mesh, and in instances where two minerals contain the same valuable constituent. The commonly occurring rutile-ilmenite mixture is one example. The time required for analysis, once the procedure is standardized, is of the order of 30 to 45 min. It may be more reliable than grain counting in the fine size range and much less time-consuming in general. For this specific investigation on taconite ores, X-ray diffraction proved the existence of goethite and hematite mixtures in what some have called limonite.

Summary: The mineral content, goethite and hematite, was determined in five taconite samples from the Wisconsin Gogebic Range by a quantitative X-ray diffraction method developed by calibration of a chart-recording X-ray spectrometer with standard samples containing the major minerals of the ores. The measured goethite diffraction intensities were found to be directly proportional to the content of goethite in various mixtures of goethite, quartz, and hematite. The measured hematite diffraction intensities, however, were affected by the relative percentages of quartz and goethite present in the mixtures of the three minerals. To determine the content of hematite in the samples it was therefore necessary to employ a set of curves made from standard samples in which the amounts of the three constituents were varied.

Acknowledgment

The writers express their appreciation for the co-operation of the faculty and staff at the University of Wisconsin and in particular to Professor E. R. Shorey, Mining and Metallurgy Dept., for providing the research facilities and to Professor M. L. Jackson, Soils Dept. for the use of the X-ray diffraction equipment. Funds for this work were contributed by the Engineering Experiment Station of the University of Wisconsin.

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Corrections

In the December 1954 issue: TP 3900L. Effect of a Variable Surface Layer on Apparent Resistivity Data. By Harold M. Mooney. P. 1211, Fig. 6, curves *F* and *G*: An anomalous behavior is apparent for electrode separations greater than 5 units. Detailed work in another connection makes it appear that this effect is not real but originated in the integration process. For large electrode separations, curves *F* and *G* in Fig. 6 should follow the general trends shown in Fig. 5.

In the December 1954 issue: TP 3931A. Diamond Drilling Problems at Rhokana. By O. B. Bennett. P. 1188, column 2, par. 6, should read. Twenty stopers using 80 diamond drills, as well as 45 percussion machines, are now employed to break 350,000 tons monthly, whereas 320,000 tons were broken previously by 34 stopers.

The term *stoper* as used in this paper refers to a European ganger in charge. These gangers direct crews of Africans, usually 12 to 14 in number, who run six machines, either diamond drills or percussion machines.

In the February 1955 issue: TP 3872L. Geophysical Case History of a Commercial Gravel Deposit. By Rollyn P. Jacobson. P. 158. Acknowledgment should have been given Washington University, St. Louis, under whose auspices the work covered in this article was done. The article represents Mr. Jacobson's Master's degree in geophysics.

Magnetic Surveys Over Serpentine Masses, Riley County, Kansas

by Kenneth L. Cook

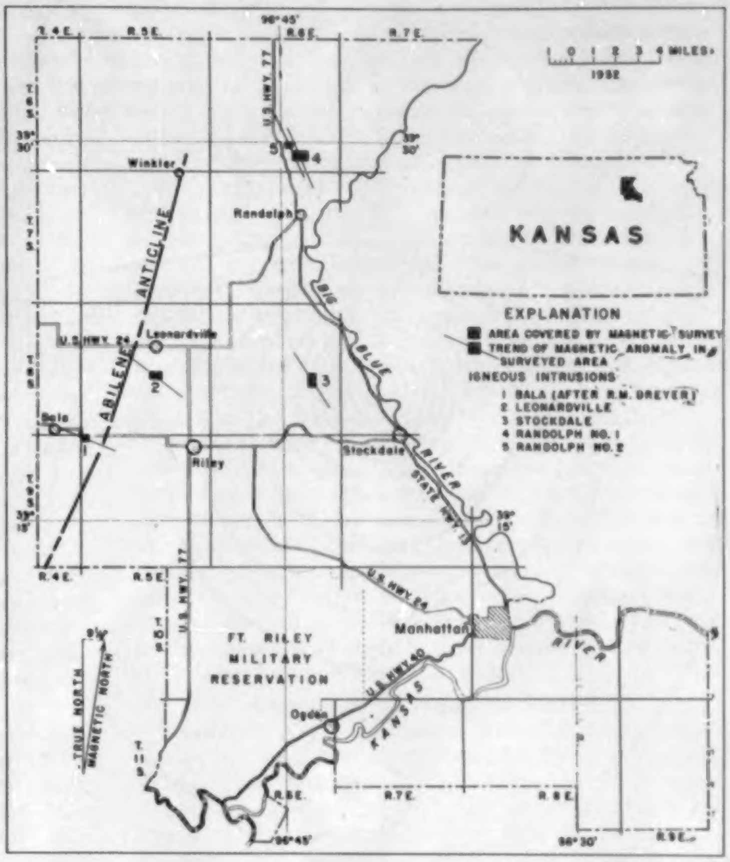

Fig. 1—Sketch map of Riley County, Kansas, showing areas covered by magnetic surveys and trends of magnetic anomalies. (Base map after Kansas State Highway Dept. Location of Abilene anticline after Wallace Lee.)

THE five serpentine masses exposed within the northern half of Riley County, Fig. 1, constitute a major part of the few exposures of igneous rock in Kansas.[1] Although not many subsurface data are available for this part of Riley County,[2] six deep wells[3] indicate that the basement complex lies between 2500 and 3000 ft below the earth's surface. A northwestward-trending ridge in the present basement surface, which extends across the northern half of Riley County, is indicated on Mettner's contour map.[4]

The serpentine masses lie in a region that was active during Pennsylvanian and Permian time along two main tectonic trends, which may, in part at least, have developed contemporaneously.[3] One trend is northeasterly, as evidenced by the Nemaha anticline, the Abilene anticline, the Voshell anticline, and many other smaller northeastward-trending folds. The other trend is northwesterly, as evidenced by the central Kansas uplift, the Salina basin syncline, and smaller northwestward-trending folds. The area of the Abilene anticline was actively deformed during much of this time, and the present surface rocks, for the most part Permian in age, show many normal faults.[5]

The Bala and Leonardville intrusions lie within a mile of the axis of the Abilene anticline, Fig. 1, as mapped by Wallace Lee;[3] the Randolph No. 1 and Randolph No. 2 intrusions lie within about 5 miles of the axis; and the Stockdale intrusion lies within about 8 miles of the axis. The igneous rocks have intruded horizontal or gently dipping limestones and shales that are late Permian in age.[6] The period of intrusion, according to Moore and Landes, was probably Cretaceous.[1]

At present a detailed description of the petrography is available for only the Bala intrusion. Moore and Haynes[7] describe the rock at Bala as a green, serpentinized, porphyritic, peridotite breccia containing inclusions of shale. The ground mass consists chiefly of serpentine and calcite with considerable chromite (5 to 10 pct) and some magnetite. The phenocrysts consist principally of altered olivine with some altered augite and biotite.

Although probably different in petrographic details, all the serpentine masses are somewhat similar in that 1) they consist of a dark green, fine-grained ground mass of igneous rock containing many xenoliths composed of fragments of the neighboring sedimentary rock; 2) they tend to form small mounds on the landscape, thus indicating their greater resistance to weathering and erosion; and 3) they are magnetic.

Previous Magnetic Survey of the Bala Intrusion: To the writer's knowledge, only the Bala intrusion had been surveyed with a magnetometer prior to the magnetic surveys discussed in this paper. Dreyer[8] interprets the intrusion as a vertical, eastward-plunging dike, on the basis of the results of his magnetic survey, Fig. 1, with a vertical magnetom-

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Discussion on this paper, TP 4019L, may be sent (2 copies) to AIME before July 31, 1955. Manuscript, Aug. 4, 1954. New York Meeting, February 1952.

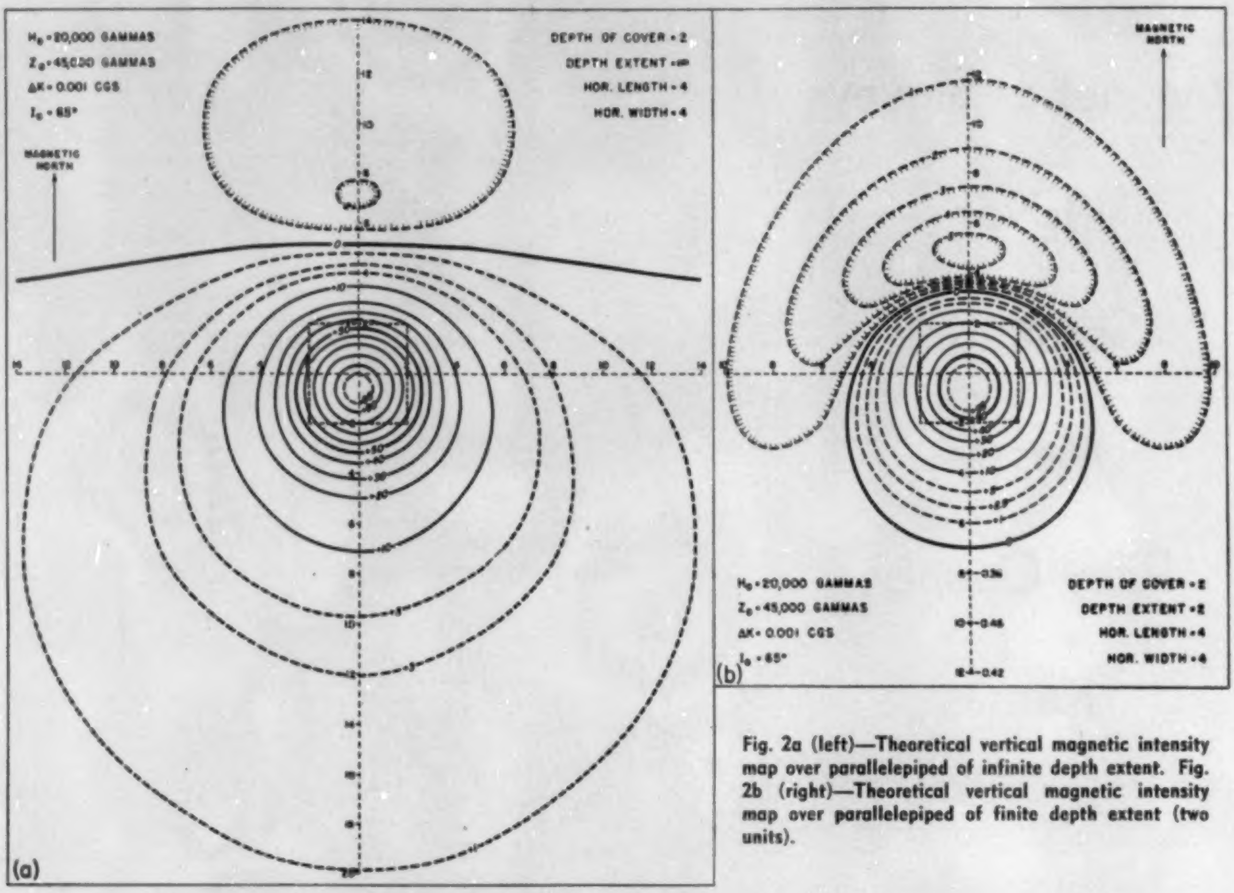

Fig. 2a (left)—Theoretical vertical magnetic intensity map over parallelepiped of infinite depth extent. Fig. 2b (right)—Theoretical vertical magnetic intensity map over parallelepiped of finite depth extent (two units).

eter. The magnetic anomaly of 3500 gammas is approximately 1000 ft long and trends approximately N. 69° W. Test drilling across the dike confirms that the walls of the dike are vertical. Test drilling along the strike of the dike indicates that the serpentine mass exposed on the mound forms an intrusive neck and that the mass on each side, which was not intruded as high, forms shoulders.[8]

Instruments and Field Techniques Used in Survey: A standard, temperature-compensated Askania vertical magnetometer with a sensitivity of 29 gammas per scale division was used throughout the measurements. About 2700 magnetometer stations were taken over a total traverse distance of 19 miles. The traverses were spaced 25 or 50 ft apart over and in the vicinity of the serpentine masses and 100 to 300 ft apart in bordering areas. The magnetometer stations were taken at 20 or 25-ft intervals over and in the vicinity of the serpentine masses and 50 or 100-ft intervals in bordering areas. To obtain the regional magnetic value for the area surrounding each serpentine mass, readings were generally taken along two or more traverses that extend for distances of 1000 to 1500 ft on each side of the exposed serpentine mass. Diurnal corrections were not applied to the data because of the large anomalies obtained, although base stations were carefully taken to detect any magnetic storms.

Theoretical Considerations: Interpretation of the vertical magnetic anomalies presented here has been facilitated by a study of some of the theoretical magnetic anomalies, based on the induction theory, that have been computed by Koenigsberger[9] for ellipsoids of rotation and by Ballarin[10] and Vacquier and others[11] for vertical parallelepipeds. For example, Fig. 2 shows the theoretical vertical intensity anomalies, after Ballarin, over a vertical parallelepiped of infinite depth extent (Fig. 2a) and of finite depth extent (Fig. 2b), in an area where the magnetic inclination is assumed to be 65°. As the magnetic inclination in Riley County, Kan., is about 69°, the theoretical anomalies given by Ballarin can be used qualitatively as a guide in the interpretation of some of the features found on the vertical magnetic intensity maps in the surveyed areas in Riley County.

For the vertical parallelepiped of infinite depth extent, Fig. 2a, the central positive magnetic high, offset to the south of the central axis of the parallelepiped, is flanked by a negative center in a magnetic north direction and a gentle positive slope decreasing to the south. The gradient of the positive magnetic contours is much less to the south of the body than to the north. The zero contour trends roughly east-west in the vicinity of the body, and the magnetic trend of the anomaly as a whole is in the direction of magnetic north.

For a vertical parallelepiped with the same horizontal dimensions and depth of cover as in the previous theoretical example, but with a finite depth extent of two units, Fig. 2b, the positive high is less pronounced and the negative magnetic center more pronounced than in the previous example. Though somewhat nearer the central axis of the body than in the previous case, the magnetic low north of the body, Fig. 2b, still lies a distance of about three units (i.e., three-fourths of the horizontal dimentions of the body) north of the north edge of the body. The zero contour envelops the body. Though not shown on the contour interval used in Fig. 2b, some negative contours also envelop the body if a smaller contour interval is chosen. At distances of

8, 10, 12, and 14 units south of the central axis of the body the computed anomalies are −0.36, −0.46, −0.42, and −0.26 gammas respectively, if Ballarin's formulas are used. All these values except the last are indicated in their proper position in Fig. 2b. Thus a magnetic minimum exists south of the body in the vicinity of the −0.46 gamma anomaly. Along the magnetic trend between the positive high and the zero contour south of the body the gradient of the anomaly is much *less* than the gradient at the corresponding location for the infinite body. It should be emphasized that the magnetic trend of the anomaly as a whole remains in the direction of magnetic north, as in the previous case.

The characteristic feature of a vertical magnetic intensity high completely surrounded by a recognizable negative anomaly can be used in northern magnetic latitudes as a criterion of the finite depth extent of the main mass causing the anomaly.[18] For a magnetic inclination of 66°, Koenigsberger,[9] using the induction theory, demonstrates that negative contours of vertical magnetic intensity at the earth's surface envelop buried magnetic spheres, oblate spheroids, and prolate spheroids. There is general agreement in the character of the vertical intensity anomalies computed by Ballarin for parallelepipeds of finite depth extent and for those computed by Koenigsberger for prolate spheroids.

Vacquier[11] gives the total magnetic intensity anomalies over various vertical parallelepipeds for different values of magnetic inclination. The bodies are of different sizes and attitudes relative to the earth's magnetic field and are of both finite and infinite depth extent. For large magnetic inclinations, the general character of the total magnetic intensity anomalies can be used as an approximate guide in the interpretation of vertical magnetic intensity anomalies. To the writer's knowledge, theoretical magnetic curves for a *dipping* cylinder, parallelepiped, or spheroid, suitable for use in the interpretation of some of the observed anomalies presented in this paper, have not yet been published.

In analyses of the type of anomalies given in this paper, as well as in general, a serious ambiguity in the interpretation often arises because the proportion of remanent to induced magnetism is not known. The greater the degree of remanent magnetization existing in the mass as a whole, the more reliance may be placed on the pole and line theory of interpretation. Contrariwise, the less the degree of remanent magnetism, the more reliance may be placed on the induction theory of interpretation.

The induction theory can probably be used in analysis of the anomalies presented in this paper for a first-order approximation of existing geologic conditions. However, the strong polarization effects at the margins of at least one serpentine mass and the inverse remanent magnetization effects that occur locally within at least one serpentine mass impose certain minor limitations on the usefulness of this theory that should be considered in any careful analysis of the magnetic data.

Results of the Magnetic Surveys

Randolph No. 1 Intrusion: The Randolph No. 1 intrusion forms a mound about 10 ft high, Fig. 3a. A mantle of soil probably not more than 5 ft thick covers the mound, so that few outcrops are to be found. Fresh pieces of igenous float found along a recently dug contour ditch on the flanks of the mound contain a dark magnetic mineral, probably

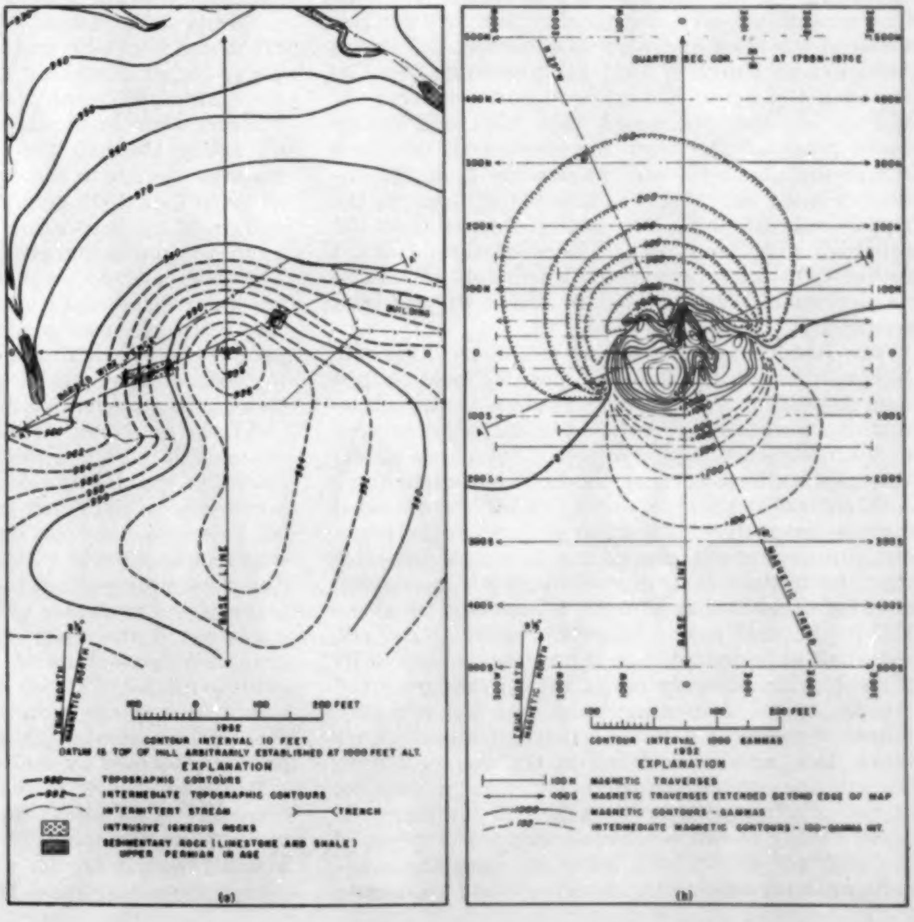

Fig. 3a (left) — Topographic and geologic outcrop map, Randolph No. 1 intrusion. (Topography and test trench data after K. L. Parish and C. F. Crumpton, USGS.)

Fig. 3b (right)—Vertical magnetic intensity map, Randolph No. 1 intrusion. Magnetic survey by K. L. Cook and C. K. Moss.

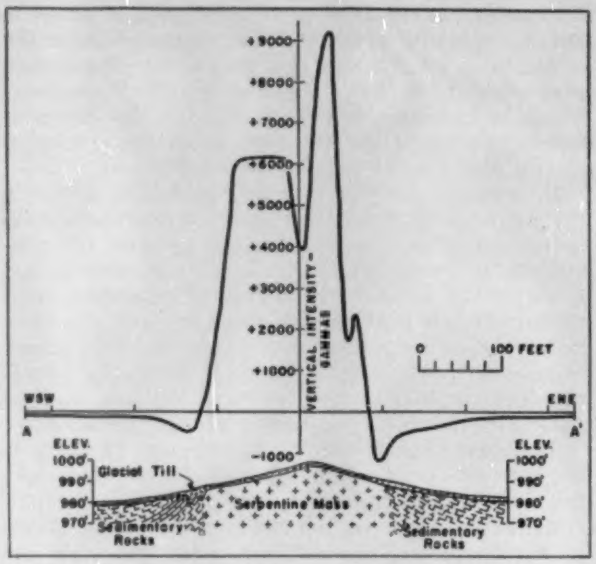

Fig. 4 (above)—Geologic cross-section (after Parish and Crumpton) and vertical magnetic intensity profile *AA'* over Randolph No. 1 intrusion.

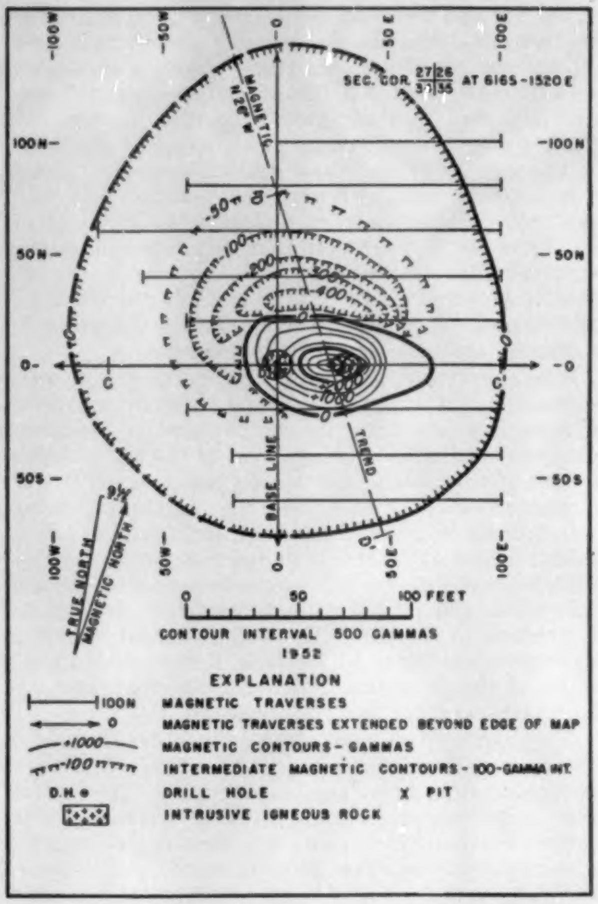

Fig. 5 (right)—Geologic outcrop map and vertical magnetic intensity map, Randolph No. 2 intrusion. Note: Limestone outcrop at ON-175E (beyond edge of map). Magnetic survey by K. L. Cook.

magnetite or chromite, which occurs both as veinlets in the serpentine mass and as large crystals disseminated in variable amounts within the serpentine mass. The apparently local variations in the quantity of magnetic material present in the serpentine mass suggests that the magnetic susceptibility of the igneous rock is highly variable. The contact between the igneous and sedimentary rocks at the west and northeast borders of the intrusion was found in 1951 by trenching, see Fig. 3a, by a Geological Survey field party under F. E. Byrne. It was discovered that the sedimentary rocks lying at and near the contact in the west trench dip about 45° westward away from the intrusive mass and that the same formations in the east trench dip about 36° eastward away from the intrusive mass, see Fig. 4. The contact is abrupt rather than gradational and is apparently vertical in the small area exposed in the west and east trenches.

The Randolph No. 1 magnetic anomaly, Fig. 3b, is characterized by a strong positive oval-shaped high flanked by a gentle positive slope to the southeast and a negative center and broad negative area to the northwest. The position of the sharp gradients that exist at or near the igneous-sedimentary rock contact lying immediately below the thin soil mantle, especially the position of those at the western and eastern margins of the intrusion, indicates that the contact at this shallow depth is roughly circular or oval-shaped with a diameter of about 250 ft. Several strong magnetic negative centers, too small to be included on the magnetic map at its present scale, were found at the surface over the interior of the serpentine mass and are probably caused by inverse remanent magnetization. Other sharp, local anomalies found at the surface within the interior are attributed to stringers or veinlets of magnetic material or variations in the magnetic susceptibility of the serpentine mass. The trend of the anomaly as a whole, including both the magnetic negative area to the northwest and the gentle magnetic positive slope to the southeast, is N 25° W.

Strong polarization effects were noted at the north and northeast margins of the serpentine mass. Large negative vertical magnetic intensity readings were obtained along traverses 50 N and 75 N in places known to be underlain with serpentine immediately beneath the thin soil mantle. On the magnetic profile in Fig. 4 the strong negative center of more than 1000 gammas overlying the northeast margin of the serpentine probably is caused largely by these polarization effects at the edges of the mass. The near-surface contacts shown in this diagram are known from the trenching work to which previous reference was made. Thus the northeastern part of the magnetic intensity curve, Fig. 4, crosses the axis of abscissas at a point lying over the interior of the serpentine mass.

As the magnetic trend of the Randolph No. 1 anomaly is not in a magnetic north direction, the intrusion apparently does not exist in the shape of a cylinder or elongated parallelepiped with a vertical axis. On the basis of the induction theory, the south-southeasterly extension of the magnetic positive slope suggests that the Randolph No. 1 intrusion is possibly a truncated cylindrical or prismatic body plunging to the south-southeast. Thus the topographic ridge extending southward from the serpentine mound, Fig. 3a, is possibly an expression of a structure in the sedimentary rocks that underlie the soil mantle in the area. This structure was probably formed by the intrusive mass at depth.

Randolph No. 2 Intrusion: The Randolph No. 2 intrusion, lying about three-fifths of a mile northwest of the Randolph No. 1 intrusion, Fig. 1, forms a small mound on the east flank of a hill capped with sedimentary rock. The igneous rock is exposed

at the top of the mound and in a shallow pit about 30 ft east of the top, Fig. 5. A 200-ft churn drillhole, located at 0.00-0.00 at the top of the mound and drilled by Charles Ammell, owner of the property, started in igneous rock, passed through about 40 ft of green igneous rock, and then penetrated 160 ft of sedimentary rock.[6]

A 5-ft cliff of limestone exposed at 0.0N-175E (beyond the east edge of the map, Fig. 5) and a probable outcrop of limestone at about 0.0N-200W (beyond the west edge of the map area, Fig. 5) indicate that at the surface the igneous rock does not extend far to the east or west of the igneous outcrops shown in Fig. 5.

The Randolph No. 2 magnetic anomaly is characterized by a strong positive center lying over the exposed serpentine mass and a negative center lying to the north-northwest of the main positive center. The horizontal extent of the positive anomaly indicates that the top of the mass, lying immediately beneath the thin soil mantle, probably does not exceed 60 ft in the longest horizontal dimension. The fact that the negative anomaly completely surrounds the area of positive anomaly, although the negative anomaly is small to the south and east, suggests that the depth extent of the main serpentine mass is small,[18] see Fig. 2b.

On the basis of the induction theory the anomaly suggests that the Randolph No. 2 intrusion is possibly a south-southeasterly plunging, fingerlike pipe. The fact that the drillhole penetrated the serpentine mass supports the possibility of a south-southeasterly plunge. At surface the pipe is probably roughly circular with a longest horizontal dimension not exceeding 60 ft. Though the main serpentine mass is apparently of finite depth, the magnetic data do not preclude the possibility that a small igneous feeder may extend to great depth.

It is doubtful that the Randolph No. 1 and Randolph No. 2 intrusions connect at depth unless it be at a depth of more than 500 ft. Although traverses 0.0E and 500N on the Randolph No. 1 grid, see Fig. 3b, were extended to 2000N and 1500W respectively, no anomaly suggestive of a near-surface connecting dike or vein between Randolph No. 1 and Randolph No. 2 was found.

Stockdale Intrusion: The Stockdale intrusion is exposed in a stream bed so that the longest dimension of the exposure is approximately 140 ft, see Fig. 6a. A few isolated exposures of the serpentine mass are found within 30 ft of the main exposed mass. Exposures of sedimentary rocks in stream beds are found about 350 ft northeast and 220 ft south, respectively, of the main exposure. The contact of the igneous and sedimentary rocks is not exposed. Unlike the other serpentine masses, the Stockdale intrusion does not form a mound.

The Stockdale magnetic anomaly, Fig. 6b, is similar to the Randolph No. 1 anomaly and is characterized by a strong positive area flanked by a broad negative area to the northwest and a gentle positive slope to the southeast. The area of strong positive

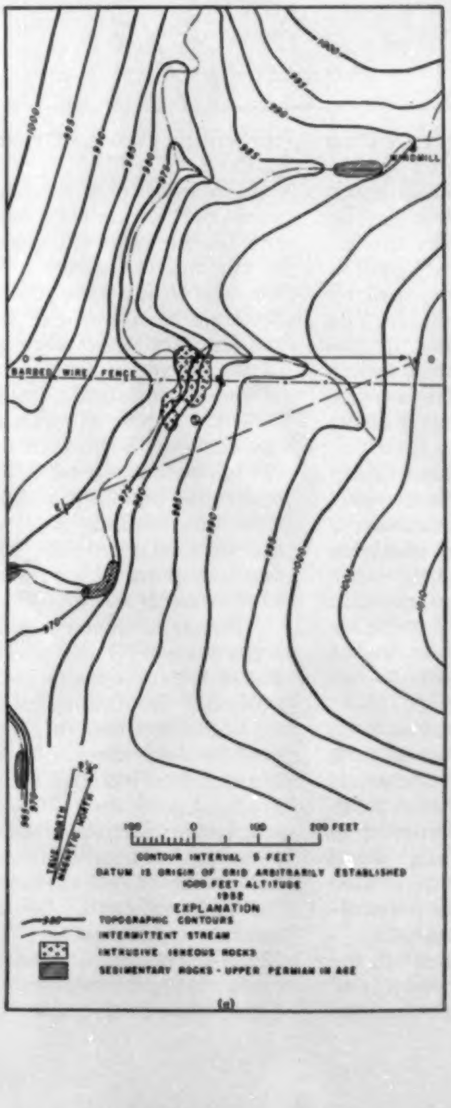

Fig. 6a (left)—Topographic and geologic outcrop map, Stockdale intrusion. (Topography after M. E. Davis and C. L. Harr, USGS.)

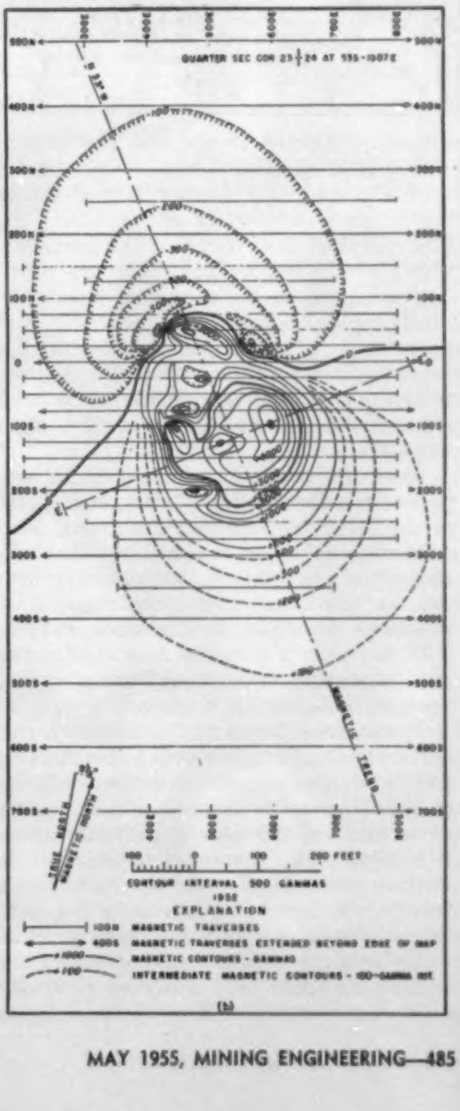

Fig. 6b (right)—Vertical magnetic intensity map, Stockdale intrusion. Magnetic survey by K. L. Cook and C. K. Moss.

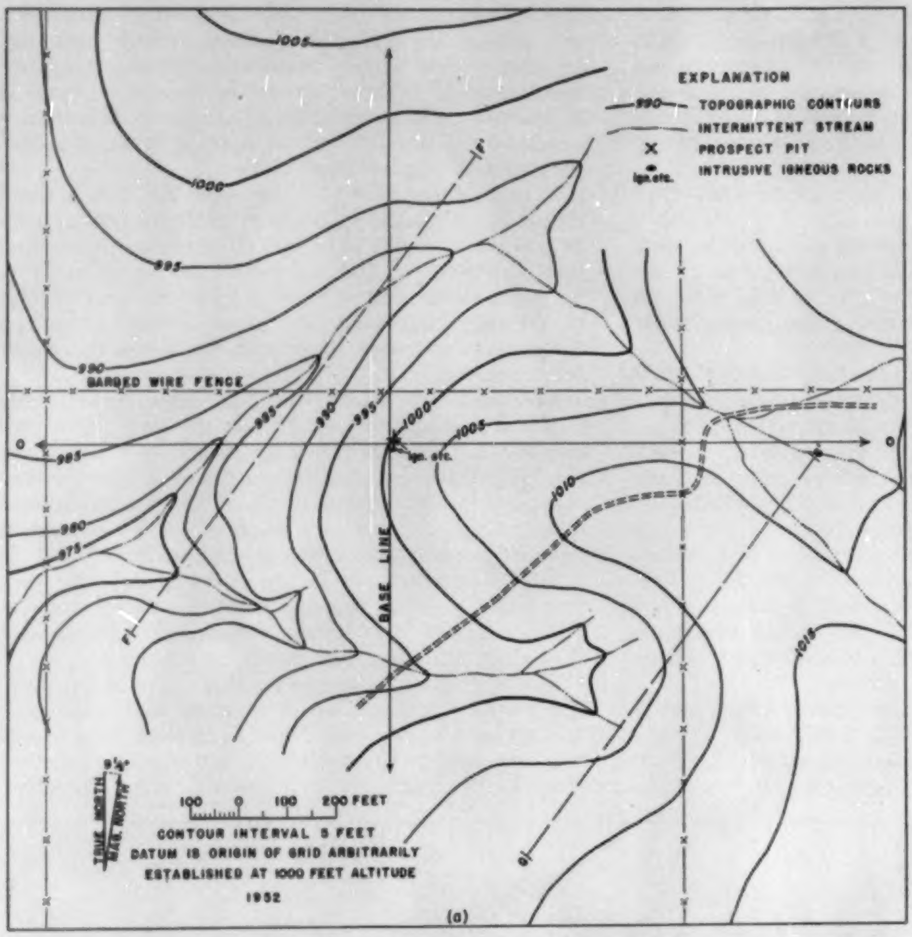

Fig. 7a—Topographic and geologic outcrop map, Leonardville intrusion. (Topography after M. E. Davis and H. Holt, USGS.)

anomaly, defined roughly as the area lying within the +1000 gamma contour, extends with northwesterly trend for about 350 ft in length and about 250 ft in width at its widest part. The magnetic peaks and valleys found at the surface over the interior of the serpentine mass are probably caused by variations in the magnetic susceptibility and by stringers or veinlets of magnetic material. The occurrence of such sharp magnetic breaks or reversals over small horizontal distances testifies to proximity of the serpentine mass to the surface within the general area of the strong positive anomaly.

Near the surface the serpentine mass probably extends to the southeast, east, and north of the outcrops. The near-surface margin of the intrusion is probably outlined roughly by the zone of sharp magnetic gradient in the vicinity of the +1000 gamma contour. The narrowing of the positive magnetic anomaly in the area north of traverse 0.0N suggests a possible near-surface narrowing of the serpentine mass in either its width, depth extent, or both, in this area.

The general trend of the anomaly, including both the magnetic negative area to the northwest and the gentle magnetic positive slope to the southeast, is N 33° W. As the trend is not in a magnetic north direction, the intrusion apparently does not exist in the shape of a cylinder or elongated parallelepiped with a vertical axis. On the basis of the induction theory, the Stockdale intrusion is possibly a parallelepiped-shaped body plunging south-southeast.

Although a mound has not yet formed over the serpentine mass, the gullying near the west and northeast margins of the intrusion suggests that the serpentine mass partly controls the present erosional pattern.

Leonardville Intrusion: Only two small exposures of igneous rock are found within the area of the Leonardville intrusion. Both lie near the origin of the magnetometer grid on top of a mound that extends to the east-southeast, as a low ridge, for a distance of about 800 ft, Fig. 7a. No outcrops of sedimentary rock were observed within the limits of the surveyed area.

The Leonardville magnetic anomaly, Fig. 7b, which is the most extensive anomaly found during the surveys, is characterized by two strong positive areas, which will be designated the north anomaly and south anomaly, respectively, and a broad negative area flanking most of the north anomaly and the northeastern part of the south anomaly. The two anomalies extend over a total distance of about 1700 ft along a N 53° W trend.

The north anomaly, which is slightly elongated in a northwesterly direction, is about 600 ft in length and 500 ft maximum width. The serpentine mass probably lies immediately beneath the soil mantle throughout the main part of the north anomaly, the near-surface margin of the intrusion probably being outlined roughly by the zone of sharp magnetic gradient near the +1000 gamma contour. The sharp magnetic peaks and valleys found at the surface over the interior of the serpentine mass testify to the shallow depth of the mass in this central area.

The north end of the serpentine mass apparently exhibits a bifurcation. The small magnetic nose at 225N-400W and the accompanying small negative center lying immediately northwest of the nose indicate that in this area a small near-surface finger

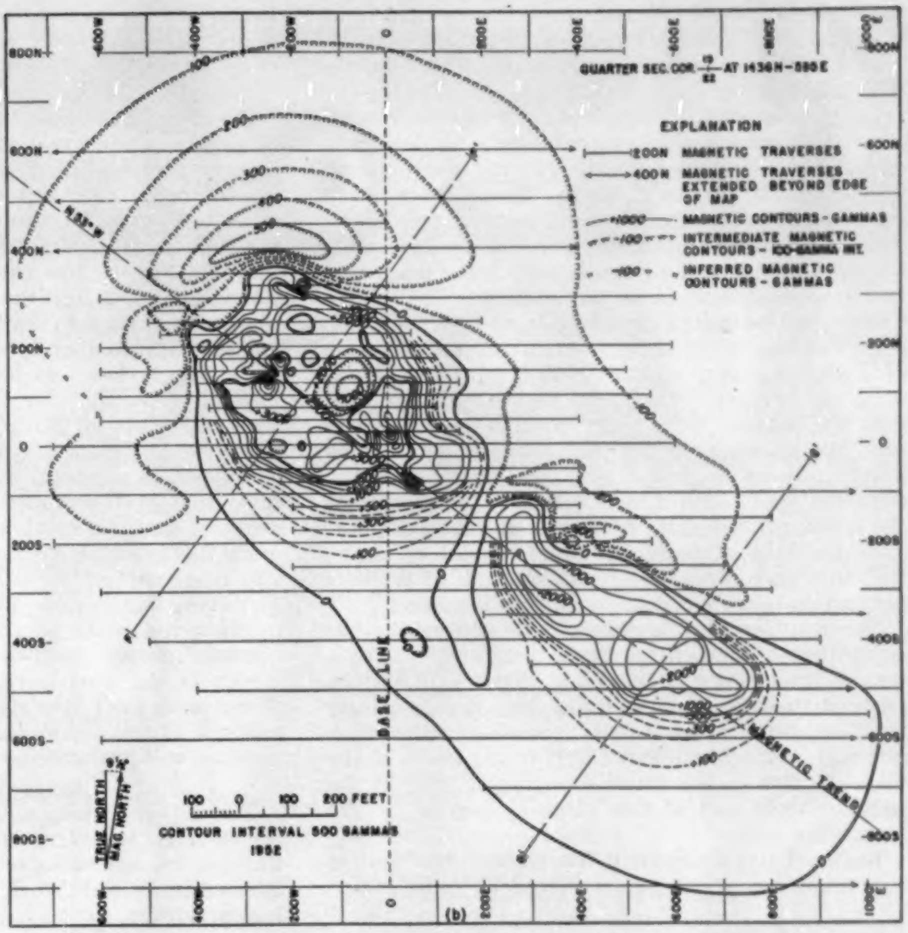

Fig. 7b—Vertical magnetic intensity map, Leonardville intrusion. Magnetic survey by K. L. Cook.

or vein of igneous rock extends in a northwesterly direction away from the main serpentine mass. A larger magnetic ridge at 350N-225W extending north-northwestward indicates that at depth in this area the main part of the serpentine mass extends in this direction. On the basis of the induction theory, the north near-surface margin of the serpentine mass is probably south of the broad, negative 500 gamma center that lies north of this ridge, see Fig. 2a.

Along magnetic profile *FF'*, see Fig. 8a, taken perpendicular to the main magnetic trend, the overall symmetry of the curve and the absence of any appreciable minima, except on the northeast flank, indicate that the side walls of the intrusion, parallel to the magnetic trend, are probably vertical or steeply dipping and that the depth extent of the intrusion is probably great. The magnetic low in the northeastern part of the profile is probably caused by the transverse magnetization effect.[18]

In the southeastern part of the north anomaly, a conspicuous narrowing of the magnetic contours indicates a possible narrowing of the serpentine mass near the surface in this area. By narrowing in this manner, the north anomaly attains a width approximately equal to that of the northern part of the south anomaly.

The south anomaly, about 700 ft long, trends northwesterly. Its character is sufficiently regular so that rough quantitative estimates of some of its dimensions can be made by using the induction theory for a dike. A few theoretical profiles, based on the standard assumptions and formulas for dikes,[18] were calculated and compared with profile *GG'*, see Fig. 8b, which is taken perpendicular to the main magnetic trend. For an assumed magnetic susceptibility excess of 0.013 cgs, a moderately good fit of the theoretical and observed curves is obtained for a rectangular-shaped, vertical dike of infinite length, infinite depth extent, 100 ft width, and 50 ft depth of cover.* The assumed susceptibility is reasonably close to the maximum value of 0.008 cgs given by Holmes[14] for the serpentine pipes and dikes that occur in the central Ozarks. Because the dike strikes northwest, the small negative magnetic center on the northeast side of the profile is probably caused by the transverse magnetization effect.

In the area lying in the direction of elongation southeast of 550S-700E, the southeasterly trend of the south anomaly is maintained, but the abrupt decrease in its magnitude suggests that the shoulder of the serpentine mass probably slopes steeply to the southeast in this area.

The narrower width and steeper gradients along the northern part of the south anomaly indicate that in this area the dike is probably both narrower and shallower than in the area of profile *GG'*. At the north end of the south anomaly the marked change in trend of the positive anomaly from northwest to north indicates that the dike probably bends to the north in this area. Near the surface in this area the dike apparently does not extend very far north of traverse 125S.

The absence of any significant anomaly, either positive or negative, between the north anomaly and south anomaly indicates that this area is probably barren of serpentine at shallow depth. It is

* A somewhat closer fit of the observed and theoretical curves could probably be obtained by computing additional theoretical curves, but this was not done, as only the order of magnitude of the dimensions was desired.

conceivable, however, that at moderate depth of perhaps a few hundred feet the two main serpentine masses are continuous, and the writer favors this interpretation. It is not known whether the present near-surface separation of the two main serpentine masses was caused merely by a vagary of the intrusion process or by faulting. The bending of the dike at the north end of the south anomaly tends to support the proposition that movement along a northward or northeastward-trending fault has separated a former single serpentine mass into two separate masses near the surface.

Thus the Leonardville intrusion is interpreted as a northwesterly trending, vertical or steeply dipping dike that is more than 1700 ft long and locally up to 500 ft wide. Interrupted by nonmagnetic rock near the surface for a short distance in its central part, the dike is probably continuous at depth. The northern part is wider and shallower than the southern part. The dike apparently bifurcates at the northernmost part. Along the direction of elongation in the southeastern part of the south anomaly, the extreme southeast shoulder or flank of the serpentine mass probably slopes steeply southeast.

The southeasterly trending dike apparently has controlled to some extent the present erosional pattern in the vicinity of the dike. In the southeastern part of the surveyed area the low northwesterly trending ridge is essentially parallel to the dike, although it is offset about 150 ft to the north of the dike. Moreover, the broad topographic nose at the northwesterly end of this ridge is formed by the serpentine mass.

Regional Implications: It has been shown that as a consequence of stresses produced by uplift, fracturing can be transverse to the axis of an anticline along its axial part[13] and that fracturing can be diagonal to the axis on the flanks of the anticline.[15, 16] The confinement of dikes to master joints or fractures in some localities has been established,[17] and it is here suggested that the igneous masses in Riley County may be intruded along such joints.

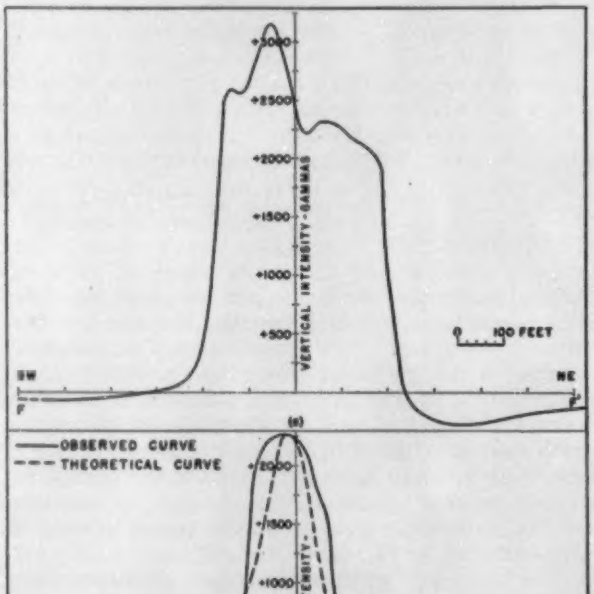

Fig. 8—(a) Vertical magnetic intensity profile *FF'* over northern part of Leonardville intrusion; (b) comparison of observed vertical magnetic intensity profile *GG'* over southern part of Leonardville intrusion and theoretical vertical magnetic intensity profile over two-dimensional dike.

The trends of the Bala and Leonardville intrusions, both of which are within a mile of the axis of the Abilene anticline, are nearly perpendicular to the axis, Fig. 1. The trends of the Randolph No. 1, Randolph No. 2, and Stockdale intrusions, lying on the flanks about 5 to 8 miles from the axis, are at an angle of approximately 45° to the axis of the anticline, Fig. 1. It seems possible that these intrusions may have been controlled by sets of joints such as those described by King[15] and Maxson,[16] although it is mere speculation that such a fracture pattern was developed as a consequence of stresses attending the formation of the Abilene anticline. Chelikowsky[17] suggests that the rotation of trends of joints in the general area of the Abilene anticline is due to strike-slip movement at depth in the basement complex. However, this process does not appear necessary to produce the observed differences in trends of the igneous masses. Additional mapping of the joint trends in the area is reported to be in progress.[18] When more joint data are available, a more detailed analysis of the significance of the trends of the intrusions will probably be possible.

Acknowledgments

The author expresses appreciation to members of the geology staff and to students at Kansas State College, too numerous to mention individually, who assisted in the field work; to F. E. Byrne, U. S. Geological Survey, for his cooperation and advice during the surveys and for the topographic and geologic maps made under his supervision; to C. K. Moss, U. S. Geological Survey, for his able assistance in the field during part of the survey; and to F. C. Frischknecht, D. R. Mabey, C. K. Moss, and V. D. Nay, for compiling much of the data and maps.

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aime news

Rocky Mountain Minerals Conference Advance Program

Plans for the second Rocky Mountain Minerals Conference to be held in Salt Lake City October 6 to 8 are progressing rapidly. The Minerals Beneficiation Div. is also holding its fall meeting in conjunction with the Salt Lake City event. The conference precedes the gathering of the American Mining Congress, making it possible to attend the latter meeting at Las Vegas, as well. A special train will leave Salt Lake City Sunday morning for Las Vegas.

The ladies have not been forgotten, and teas and fashion shows sponsored by the WAAIME are scheduled.

Advance Program

Wednesday, October 5—Registration 1:00 to 5:00 pm

Thursday, October 6—Morning Technical Session

1. Uranium Occurrences West of Colorado Plateau
2. Geneva Works Water Supply and Water Treating System
3. Control Engineering
4. Chemical Refining of Tungsten

Welcoming Luncheon—Speaker: Hon. J. Bracken Lee, Governor of Utah

Afternoon Technical Sessions

1. Rare Metals
2. Quantitative Approach to Material Bulk Handling Problems
3. Speed-up of Grinding Mills at Hayden
4. Processing of Phosphate Rock

Cocktail-Buffet Party

Friday, October 7—Morning Technical Session

1. Beneficiation of Uranium Ores
2. Underground Mining of Phosphates
3. Forty-two Inch Vibrating Rod and Ball Mill
4. Mining Education

MBD Luncheon—Speaker: W. W. Mein, Jr., AIME Vice President

Afternoon Technical Sessions

1. Uranium Mining Methods
2. Student Prize Paper (University of Utah)
3. Western Coals
4. Taconites

Saturday, October 8—7:00 am—Scotch Breakfast

Morning—Symposium: Sampling of Mining Prospects for Process Testing and Mill Design

Afternoon—Field Trips

1. Geneva Steel Plant
2. Bingham & Lark
3. Magma & Arthur Mills
4. Garfield Refinery & Smelter
5. Western Phosphates
6. Vitro Uranium
7. Kennecott Research & Engineering Center

Cocktails—Dinner Dance

Sunday, October 9—Special train leaves at 9:05 am for Las Vegas, Nev., for AMC, arriving 3:55 pm

Around the Sections

• **Charles A. Steen's Utex Exploration Co., Moab, Utah, announced that the company's film, *Mi Vida*, is ready for distribution to engineering and geology departments of colleges and universities, to scientific clubs, banks, service clubs, and other groups interested in uranium production. The film, a 16-mm documentary, presents the story of Mi Vida operations. Requests for the 45-min film should be submitted to Utex Exploration Co., Moab, Utah.**

• **Montana Section** held its annual meeting at Great Falls, April 23, in the Rainbow Room of the Rainbow Hotel. S. E. Runser, gas engineer, Montana Power Co., spoke on "Gas Operations of the Montana Power Co." The Section also held its annual joint meeting with the Montana Society of Engineers. A. E. Millar, general manager, Yerington mine, presented an illustrated talk on "Anaconda's Yerington Operations."

• The **Adirondack Section** met at the Potsdam Club, Potsdam, N. Y. Donald Paro, public relations dept., Aluminum Co. of America, discussed techniques for properly informing employees about company operations. The Section also toured the whole St. Lawrence power project, viewing dikes, dams, and bridges, getting a briefing on the geological and engineering factors involved in construction. The Section recently added Vermont to its territory. This, and growing interest in Section activities, has helped to add 18 members to the list.

• The first regular meeting of the **Minerals Beneficiation Subsection** of the **Minnesota Section** since last October was held at the Coates Hotel, Virginia, Minn. Subsection Chairman Earl C. Herkenhoff presided. Kenneth Merklin, Program Chairman, introduced A. S. Henderson, chief metallurgist for Reserve Mining Co., who introduced a film, *Taconite*.

• The **Reno, Nevada Subsection** heard a report on the Chicago Annual Meeting by J. N. Butler, **Nevada Section** Secretary-Treasurer. Matters taken up by the Council of Delegates were discussed, particularly as related to Subsection finances.

• Thomas B. Nolan, assistant director of the U. S. Geological Survey, was the guest speaker at a recent dinner-meeting of the **Washington, D. C., Section.** Meeting at the Cosmos Club, the group heard Mr. Nolan discuss the "Outlook for Nonrenewable Resources of the Future."

• The **Lima, Peru Section** had something different in the way of meetings when the entire membership repaired to the Naplo beach home of Ernesto Baertl, Section Vice Chairman, some 40 miles from Lima. The group canceled its regular luncheon meeting to attend the beach party arranged by the WAAIME. The Section treasury contributed three kegs of beer. Members, wives, and children started Operation Baertl when about 50 cars left Lima for the beach at Naplo. Food and beer disappeared like magic as section member Al Barrios strummed his guitar and sang. Bathing, boat trips, and card playing contributed to what ended up as a

(Continued on page 490)

memorable day and the forerunner of a tradition.

• Delwin D. Blue, superintendent of the Boulder City Station of the U. S. Bureau of Mines, spoke at the first meeting of the recently reactivated **Southern Nevada Subsection.** He reviewed the reorganization of the USBM and the anticipated greater service to the southern Nevada mineral industry. John S. Anderson was appointed Chairman of the Membership Committee for the Section. He also gave an account of the recent Annual Meeting at Chicago.

A new 16-mm sound and color film, *Fiery Magic*, has been issued by National Carbide Co., a division of Air Reduction Co. Inc. Consecutive steps in the manufacture of carbide are demonstrated by an animated flow chart. Colorful sights of the process itself were shot at various National Carbide plants. The 23-min film may be borrowed from district offices of the Air Reduction Co., National Carbide outlets, or directly from National Carbide Co., 60 E. 42nd St., New York 17, N. Y.

A new all-Institute directory was announced in the March issue. Copies of the directory may be obtained by using the coupon which appeared on page 301, Mining Engineering, March 1955.

President Smith Tours Western Sections

One of the stops made by President H. DeWitt Smith during his recent western trip was at Inspiration, Ariz. President Smith is flanked on the left by Carl E. Reistle, President-Elect 1956, and Carroll Weed. On the right are Roy O'Brien and P. D. I. Honeyman.

Among those who welcomed Mr. Smith and Mr. Reistle to Arizona were Lawrence Ormsby, mine superintendent, and Lyle M. Barker, manager of the Morenci mine.

Upper Peninsula Section

Mr. Klapka and some of his core bits, reaming shells, and diamonds.

The Upper Peninsula Section recently organized three subsections, Exploration, Mining, and Minerals Beneficiation. The Exploration Subsection held its organizational meeting with K. J. Klapka, core bit engineer for the Wheel Trueing Tool Co., Detroit, speaking on "Diamonds and Their Uses." A total of 49 attended the first meeting of the group at the Mather Inn, Ishpeming, Mich.

Mr. Klapka illustrated his talks, which emphasized core drilling, with a number of core bits and reaming shells. He also showed his audience a variety of industrial diamonds and gem diamonds.

Arnold L. Brown is chief mining engineer, Trans-Western Uranium Corp., Salt Lake City. He was with Kennecott Copper Corp., Ruth, Nev.

George F. Zerfoss is mining valuation engineer, Bureau of Land Management, Las Vegas, Nev. He was shift foreman, Phelps Dodge Corp., Morenci Open Pit, Morenci, Ariz.

William A. Griffith has been transferred from the research dept., The New Jersey Zinc Co., Palmerton, Pa., to the Bertha Mineral Div., Austinville, Pa.

John Kenneth Jones is field geologist, Anaconda Copper Mining Co., Reno, Nev. He was with International Smelting & Refining Co., Salt Lake City.

D. W. Parkin has been appointed chief engineer, Stephens-Adamson Mfg. Co., Aurora, Ill. Mr. Parkin, who has been with this company since 1939, was formerly assistant sales manager.

Clyde Williams, president and director of Battelle Institute, Columbus, Ohio, was awarded the honorary degree of Doctor of Laws by Marietta College in Ohio at the recent Founder's Day Convocation. Mr. Williams also holds honorary doctorates from Case Institute of Technology, University of Utah, Michigan College of Mining and Technology, and Ohio State University.

Ralph M. Perhac, geologist, with the Albuquerque suboffice of AEC for nearly two years, is now field geologist with American Overseas Petroleum Ltd. and is in Australia.

Whitman G. Rouillard is manager of American Smelting & Refining Co.'s Tacoma, Wash., smelter. Formerly manager of the Garfield plant, Salt Lake City, Mr. Rouillard has been with Asarco since 1926 when he was graduated from Tufts College.

Walter A. Dean, chief metallurgist, Aluminum Co. of America's Cleveland, Ohio, Works, has been named to coordinate technological developments in titanium with Alcoa's expanding titanium activities, particularly in the forging field. He has been active in research and process metallurgy with Alcoa for the past 25 years and was prominent in the development of a number of aluminum alloys, particularly free-machining 2011 alloy. A member of the American Society of Metals, the British Institute of Metals, the American Foundrymen's Society, Mr. Dean was recently elected an AIME Vice President.

Bernard A. Moser, formerly chief engineer, Wilmot Engineering Co., White Haven, Pa., has joined the staff of Wilferd L. Roller Co., 206 W. Market St., Pottsville, Pa., as designing engineer.

PERSONALS

VIOLA R. MacMILLAN

Viola R. MacMillan has been reelected president of the Prospectors & Developers Assn., Toronto, for the 12th consecutive year. Also reelected were **Cyril T. Young,** vice president, **Fred H. Jowsey,** secretary, and **Mrs. D. I. Drewe,** assistant secretary.

Frederick T. Quiett, formerly chief engineer, New World Exploration, Research & Development Corp., Van Nuys, Calif., is chief engineer, Perini Mining Co., Grand Junction, Colo.

George W. Boulter, Joy Mfg. Co., has been named sales engineer for the Idaho and eastern Washington areas, with headquarters in Kellogg, Idaho. Prior to this appointment, Mr. Boulter was with Joy's Knoxville, Tenn., district office for two years. Before joining the company in 1953 he had served in mining exploration and operation capacities for more than ten years. Mr. Boulter replaces **Harry W. Pierson** and **Robert L. Frazer** who have been transferred to Joy's new field office at Grand Junction, Colo., and to the Denver district office respectively.

H. H. McCreedy is employed as a scientific officer of mines, Radioactivity Div., Mines Branch, Dept. of Mines & Technical Surveys, Ottawa. Mr. McCreedy was research engineer, mining dept., University of Alberta, Edmonton.

E. J. Jackson, who was chief chemist, Cia. Mineira do Lobito in Angola, is with Anglo American Corp. of South Africa Ltd. in Johannesburg.

Hubert O. De Beck has been appointed evaluation engineer for the production dept., Baroid Div. of National Lead Co., Houston. Mr. De Beck was initially engaged as the consulting mining engineer to this division last year after fulfilling a long-term commitment to the U. S. Bureau of Mines, Norris, Tenn.

John L. Reuss is a metallurgical engineering trainee with Oliver Iron Mining Div., Eastern District, Virginia, Minn.

James McKim is industrial specialist, U. S. Operations Mission to Spain. He was with the USRO offices in Paris.

Robert J. Wright has resigned as chief, Geologic Branch, Atomic Energy Commission, Grand Junction, Colo., to join the exploration staff of Climax Uranium Co., also of Grand Junction.

William W. Wittmeyer, who was general supervisor, Vanadium Corp. of America, Ricran, Peru, has been transferred to Naturita, Colo.

Roshan B. Bhappu has resigned as project engineer, Colorado School of Mines Research Foundation Inc., Golden, Colo., and has joined Miami Copper Co., Miami, Ariz., as metallurgist.

Carl M. Loeb, Jr., held the position of chairman for the Nonferrous Metals Div. of the 1955 April Cancer Crusade of the New York City Cancer Committee. Mr. Loeb is consultant and director, Climax Molybdenum Co., New York.

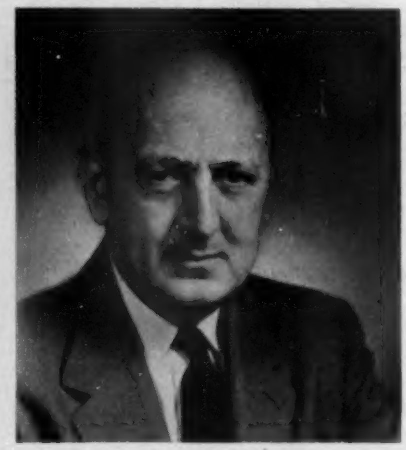
Stanley F. Johnsen, mining engineer with Carmac Coal Co., Marion, Ill., for the past four years, is now a geologist with Hecla Mining Co., Burke, Idaho.

Herbert D. Imrie has been elected to the executive committee of the American Council of Independent Laboratories Inc. Mr. Imrie is president of Abbot A. Hanks Inc., San Francisco, one of the oldest independent laboratories in the U. S. Mr. Imrie joined the firm in 1906, became vice president in 1924 and president in 1939.

Merle H. Guise is in Australia on exploration work. He also plans to visit the Orient. His address is c/o American Express, Sydney, Australia.

D. K. Robinson has resigned as assistant manager of Sungei Way Dredging Ltd., Sungei Way, Selangor, Malaya, and is surveyor for Sons of Gwalia Ltd., Gwalia, Western Australia.

Charles Will Wright left New York March 29 for Italy where he will work with the technicians of Ente Zolfi Italiani to raise recovery and lower costs at EZI's Sicilian sulphur properties.



L. S. WILCOXSON

L. S. Wilcoxson, vice president in charge of research, Babcock & Wilcox Co., New York, since 1945, has been appointed vice president in charge of the Boiler Div. This division has six manufacturing plants in the U. S. Mr. Wilcoxson joined Babcock & Wilcox in 1926 and was made an executive assistant in the engineering dept. in 1931. He holds several patents relating to the equipment used in the generation of steam and is the author of numerous technical papers in his field. Mr. Wilcoxson is a director of the Bailey Meter Co. of Cleveland and Diamond Power Specialty Corp., Lancaster, Ohio.

J. E. Douglas is assistant district sales manager of Joy Mfg. Co.'s El Paso territory. Mr. Douglas joined the company in 1945. His first sales assignment was in the Birmingham-Knoxville territory. In 1950 he was transferred as sales engineer to the Phoenix area of the El Paso district where he remained until his recent appointment.

C. KREMER BAIN

C. Kremer Bain has retired from St. Joseph Lead Co., Bonne Terre, Mo., to enter the private consulting field and promote his patents on shaft sinking methods and equipment. During the major portion of his 34 years of service with St. Joseph Lead Co., Mr. Bain was in charge of mining, milling, prospecting, and administrative work of the Northern Div. with headquarters at Bonne Terre. He was active in developing a mechanization program as well as safe and economical mining practices. Mr. Bain originated and developed mine roof bolting now used throughout the mining industry. St. Joseph Lead Co. made extensive use of his services in other parts of the world as well as in southeast Missouri. His address is 410 North Newstead Ave., St. Louis.

N. M. B. Blackburn has been appointed an inspector of mines for the Federation of Nigeria. A 1951 graduate of the School of Metalliferous Mining, Camborne, England, Mr. Blackburn was formerly mining engineer with Uruwira Minerals Ltd., Mpanda, Tanganyika.

JOHN L. SPLANE

John L. Splane, general superintendent, U. S. Graphite Co. and Cía. Minera de San José, Moreno, Sonora, is now with San Francisco Mines of Mexico Ltd., San Francisco del Oro, Chihuahua.

Paul B. Jessup has been appointed secretary of Kennecott Copper Corp., New York. He succeeds **Robert C. Sullivan** who will be associated with **Seymour S. Jackson,** head of the corporation's legal dept.

Robert R. Wallace and **W. P. Pan,** Oliver Iron Mining Div., Hibbing, Minn., have both become assistant chief mining engineers for the Hibbing-Chisholm district, Mesabi iron range.

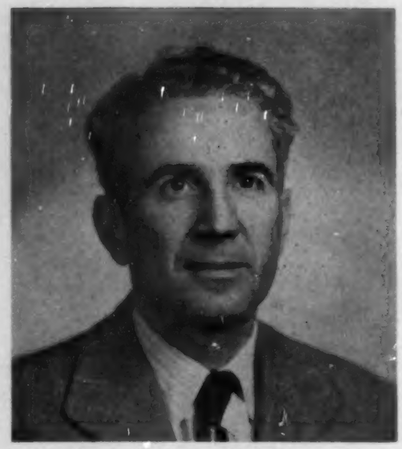
H. A. Ball has been appointed quality control manager, Metals Div., Olin Mathieson Chemical Corp., East Alton, Ill. Mr. Ball joined the Olin organization as a metallurgist in 1946.

Milton H. Ward, recent University of Alabama graduate, is employed by San Manuel Copper Corp., San Manuel, Ariz., as a junior engineer.

Gerald R. Gabel, for the past two years, mining engineer, U. S. Bureau of Mines, Joplin, Mo., is plant engineer, Drummond Dolomite Inc., Drummond Island, Mich.

Herbert Drechsler is mill engineer, Resurrection Mining Co., Leadville, Colo. He was mill shift foreman, White Pine Copper Co., White Pine, Mich.

P. F. Yopes is assistant to the chief, Div. of Minerals, U. S. Bureau of Mines, Washington, D. C. He was with the USBM in Albany, Ore.



ALAN A. SHARP

Alan A. Sharp, who had an office in Moab, Utah, where he was engaged as a mining consultant, gave up his practice to join the U. S. Bureau of Land Management as a mineral valuation engineer at the state office in Sacramento, Calif.

Harold Von Thaden, vice president and general manager of the International Div., Hewitt-Robins Inc., Stamford, Conn., left the U. S. at the end of March to visit subsidiary and affiliated companies in England, Italy, South Africa, Holland, and France. Mr. Von Thaden will meet with management officials at each of the overseas locations. He plans to return to New York in July.

Donald L. Archibald, Joy Mfg. Co., has been appointed district sales manager in the New England area with headquarters in Boston. Mr. Archibald joined the Joy organization in 1940 and served as sales engineer in New York and Butte before beginning service in the navy in 1942. In 1945 he was named sales engineer in the El Paso territory, later becoming manager of the company's Mexico City office. He was transferred to St. Louis in 1951 and remained there until his recent appointment.

James A. Briggs, assistant chief engineer, Phelps Dodge Corp., Morenci, Ariz., has been transferred to Ajo, Ariz., where he will be assistant mine superintendent.

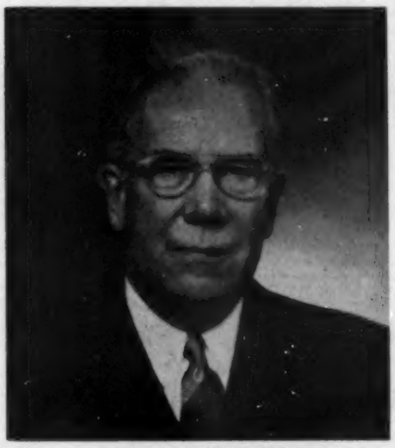
Thomas J. Hubbard, formerly maintenance and construction engineer, Hurley plant, Kennecott Copper Corp., Chino Mines Div., Hurley, N. M., has joined the Utah Copper Div. of Kennecott in the mechanical dept.

William J. Shedwick, Jr., consulting engineer of Mexico City, is currently in Quito, Ecuador. Mr. Shedwick is making geologic studies in connection with a hydraulic installation under contract to John J. Harte Co. of Atlanta. This project is financed by the Export-Import Bank of the United States and the International Bank for Reconstruction & Development in Washington.

Philip T. Stroup has been appointed assistant director of research, Aluminum Research Laboratories, Aluminum Co. of America, New Kensington, Pa. Mr. Stroup joined Aluminum Research Laboratories in 1929. He was transferred to the Metallurgical Div. in 1936 and was promoted to chief of the Process Metallurgy Div. in 1942.

Gideon A. Apell has been transferred from the U. S. Bureau of Mines Boston office to the USBM office at Butte, Mont. Mr. Apell has been with the USBM since 1941.

Clarence M. Haight retired from active work with The New Jersey Zinc Co., Franklin, N. J., April 1. He has been connected with the mining operations of the Franklin mine for over 42 years. He was mine superintendent when the mine was closed in October 1954 due to the exhaustion of the orebody. Before joining New Jersey Zinc, Mr. Haight worked in the Michigan copper district and on the Mesabi Range.



ROY H. GLOVER

Roy H. Glover, vice president and general counsel, Anaconda Copper Mining Co., Butte, Mont., was decorated in Santiago, Chile, by President Carlos Ibanez with the Order of Merit. This is one of the highest honors bestowed by the Chilean Government and one that has been awarded to only a few foreigners. Mr. Glover has contributed much to the economy of the country in connection with Chile's copper industry.

John L. G. Weysser, consulting mining engineer, recently returned from Korea. He was on a consulting engagement for a year, working on the coal mine rehabilitation and improvement program for the United Nations Korean Reconstruction Agency. On his way back to the States, he visited a number of countries in Asia and Europe. Mr. Weysser's present address is P.O. Box 15, Paxinos, Pa.

A. E. Millar has been elected president, Nevada Mining Assn. Mr. Millar is general manager, Yerington Copper Mining Div., Anaconda Copper Mining Co.

OBITUARIES

Ernest C. Bierce (Member 1919) died July 9, 1954. He was a consulting engineer, Pasadena, Calif. and a former vice president, Western Clay & Metals Co., Los Angeles. Mr. Bierce was born in Racine, Wis., in 1879 and studied in Ohio at Miami University and Western Reserve University. His early experience was gained as a chemist and assayer with Pritchett & Stanley, Mexico City, and with American Smelting & Refining Co.'s Aguascalientes plant. Returning to the U. S., he worked as a chemist and metallurgist with Old Dominion Copper Co., Globe, Ariz., and later as a metallurgist with Pacific Mines Corp., Ludlow, Calif. After working with Ore Trading Co., Coquimbo, Chile, Mr. Bierce entered private practice with E. H. Kennard in consulting, testing, and mill design in Los Angeles.

Horace R. Graham (Member 1919) died Nov. 8, 1954 of a heart attack at La Guardia Airport. He was returning to his home in New York after a visit in the South. Mr. Graham, who resigned last July as president of Anglo Chilean Nitrate Corp. and Lautaro Nitrate Co., was at the time of his death a director of Anglo-Lautaro, the Chilean Nitrate Sales Corp., the Pacific Tin Consolidated Corp., and the Minerec Corp.

He was born in New York in 1886 and following graduation from Columbia School of Mines in 1908, worked as a fireman with Nevada Consolidated Copper Co., Ely, Nev. He was a construction engineer when he left in 1910 to work for Braden Copper Co., Rancagua, Chile, and was general manager when he left there in 1919. He spent ten years as general manager of Caracoles Tin Co., La Paz, Bolivia. During World War II, Mr. Graham served as the representative in Chile of the Metals Reserve and other important Governmental agencies, including the Coordinators Committee, of which he was chairman. He was also chairman of the U. S. Inter-American Council, vice chairman of the Council for Inter-American Cooperation, and a member of the Pan American Society and Chile American Assn.

Hoval A. Smith (Legion of Honor Member 1902) of Washington, D. C., died in that city on Oct. 29, 1953. He was born at St. Ansgar, Iowa, on May 1, 1876, and graduated from the School of Mines, University of Minnesota. In 1898 he became associated with a contracting firm establishing mining plants in New Mexico and Colorado. Subsequently in 1899 as an engineer for Gillette Herzog Co. he supervised the erection of shaft details and mills at Nacozari, Sonora, and Morenci and Bisbee, Ariz.

From 1901 to 1905 he was chief engineer of Calumet & Arizona Mining Co. and was instrumental in the development of the Junction copper area in Bisbee. Later he also developed in that area the American and Warren copper deposits.

From 1905 to the date of his death he was an independent mining engineer and developer. He developed the Live Oak copper deposit in Miami, Ariz., and brought to the Calumet & Arizona the Cornelia deposit at Ajo, Ariz. In addition, he investigated and assisted in the development of various other mining properties in the U. S. and Mexico. At the time of his death he was the president of the Bluestone Copper Co. and Washington Mines Development Co.

Mr. Smith for many years was chairman of the Republican Party of the Territory of Arizona and as such was instrumental in obtaining statehood for Arizona. He later was on several occasions the Republican nominee for the Senate and House of Representatives from Arizona. He founded the town of Warren, Ariz., where he lived for many years.

Mr. Smith is survived by his

Necrology

Date Elected	Name	Date of Death
1917	D. W. Butner	Feb. 10, 1955
1941	Thomas C. Cheasley	Mar. 17, 1955
1912	Hugh M. Crankshaw	Mar. 25, 1953
1912	J. W. H. Hamilton	Jan. 11, 1955
1928	Elton Hoyt, II	Mar. 16, 1955
1928	Franklin Leonard	Mar. 13, 1955
1947	Leslie A. Rainier	Dec. 3, 1954
1920	John Roger	Mar. 7, 1955
1932	I. J. Simcox	Feb. 13, 1955
1897	Alpheus F. Williams	Unknown

widow, Mrs. Nina Roberts Smith of Washington, D. C., a son, Hugh R. H. Smith of Chevy Chase, Md., and three granddaughters.

James Underhill
An Appreciation by
M. I. Signer

With deep sorrow we record the death of James Underhill (Legion of Honor Member 1898) Apr. 22, 1954.

James Underhill was born in New York City, Apr. 9, 1871. He graduated from Harvard University with an A.B. degree in 1894. He came to Colorado in 1896, and resided in Idaho Springs continuously until his death. Mining was at its height in Clear Creek and Gilpin counties during these early years. Although extremely busy as a consulting engineer, James Underhill continued his studies and earned a Ph.D. degree from Colorado University in 1906.

He joined the staff of the mining dept. of the Colorado School of Mines in 1919 and continued this association until he retired in 1946, at the age of 75. It was my privilege to become associated with Dr. Underhill as a fellow teacher in the mining dept. in 1929. I learned early in this association of his broad knowledge in many fields—language, literature, mathematics, and music, as well as engineering. Those of us who knew and worked with Dr. Underhill can truthfully say that we are better men because of the association.

MEMBERSHIP

Proposed for Membership
Mining Branch, Aime

Total AIME membership on Mar. 31, 1955 was 22,290; in addition 1762 Student Associates were enrolled.

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The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

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Bauxite—Brazil, John E. (M)
Benton—Krause, John R. (C/S—A-M)
Stuttgart—Kazmann, Raphael G. (M)
California
Altaville—Weeks, Orrin D. (R. M)
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Bishop—Palmer, Leonard G. (A)
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San Francisco—Quist, Martin P. (M)
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Grand Junction—Dow, Vernon T. (R. C/S—A-M)
Grand Junction—Hasler, J. William (R. C/S—J-M)
Grand Junction—Lennemann, William L. (C/S—A-M)
Grand Junction—Young, Neil B. (M)
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Michigan City—Leven, Samuel (M)
Terre Haute—Philippi, L. B. (A)
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Coming Events

May 16-19, American Mining Congress, 1955 Coal Show, Cleveland.

May 19, AIME, Utah Section, joint meeting with University of Utah Student Chapter. Speaker: Eugene Callaghan, director, New Mexico Bureau of Mines & Mineral Resources.

May 21, AIME, Columbia Section, Student Meeting, State College of Washington, Pullman, Wash. Student papers program, baseball game, dinner.

May 30-June 1, Chemical Institute of Canada, annual conference, Quebec, Canada.

May 31, World Power Conference, International Executive Committee, Paris.

June 1-18, Joint Metallurgical Societies, European meeting.

June 2, AIME, Utah Uranium Subsection, 7:30 pm, Arches Cafe, Moab.

June 10-11, AIME, Central Appalachian Section, spring meeting, Phoenix Hotel, Lexington, Ky.

June 14-16, Conference on Magnetism and Magnetic Materials, AIEE, AIME, American Physical Society, Carnegie Institute of Technology, William Penn Hotel, Pittsburgh.

June 17, AIME, Spokane Subsection, Desert Hotel, Spokane.

June 18-July 3, Centenary Congress of the Société de l'Industrie Minérale, Paris.

June 20-24, American Society of Engineering Education, 63rd annual meeting, Pennsylvania State University, State College, Pa.

June 26-July 1, American Society for Testing Materials, annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

June 28-July 9, International Electrochemical Commission, London.

Sept. 25-28, American Institute of Chemical Engineers, Lake Placid Club, Lake Placid, N. Y.

Oct. 2-5, AIME MGGD fall meeting and Black Hills regional meeting of the Ind. Min. Div., Rapid City, S. D.

Oct. 6-8, AIME, Minerals Beneficiation Div., fall meeting, **Rocky Mountain Minerals** Conference, Salt Lake City.

Oct. 10-13, American Mining Congress, Metal Mining—Industrial Minerals Convention, Las Vegas, Nev.

Oct. 13-15, Annual Drilling Symposium, School of Mines and Metallurgy and the Center for Continuation Study, University of Minnesota, Minneapolis.

Oct. 17-19, AIME, IMD, fall meeting, Adelphia Hotel, Philadelphia.

Oct. 19-20, ASME, AIME, fuels conference, Neil House, Columbus, Ohio.

Oct. 27-29, AIME, Industrial Minerals Div., fall meeting, Charlotte, N. C.

Nov. 4, AIME, NOHC, Pittsburgh Local Sections, off-the-record meeting, Pittsburgh.

Nov. 13-18, American Society of Mechanical Engineers, Diamond Jubilee annual meeting, Congress, Hilton, and Blackstone Hotels, Chicago.

Feb. 20-23, 1956, AIME, Annual Meeting, Statler and New Yorker hotels, New York.

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